Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 27(3): 569 – 601 (2023)
www.ejabf.journals.ekb.eg

Environmental Assessment of Wetland Vegetation: a Case Study of Ashtum El-Gamil Protectorate, Lake Manzala, Egypt

Mona Mostafa [1,*], Mosallam H. A.[1], Youssef.A.M.[1], Hatab E.E.[2] and Hashim A.M.[1]

[1]Botany Department, Faculty of Science, Ain Shams University, Cairo, Egypt
[2]Nature Conservation Sector, Ministry of Environment, Egypt

***Corresponding Author: monamostafa@sci.asu.edu.eg**

ARTICLE INFO

Article History:
Received: April 19, 2023
Accepted: May 20, 2023
Online: June 19, 2023

Keywords:
Ashtum El-Gamil,
Floristic analysis,
Habitat destruction,
Multivariate analysis,
Soil-vegetation relationships,
Wetlands

ABSTRACT

Wise use of the Egyptian wetlands through local and national actions as a contribution towards achieving sustainable development throughout the country has been implemented. Ashtum El-Gamil Protectorate is a part of Lake Manzala and an ideal wetland habitat. Unfortunately, Ashtum El-Gamil Protectorate was subjected to many encroachments that led to biodiversity loss and habitat destruction during the last decades. Therefore, this study aimed to assess the current state of vegetation distribution and its relationship with environmental variables in the investigated area. The vegetation and soil sampling was carried out using 50 stands. Phyto-sociologically, the vegetation assessment revealed that Ashtum El-Gamil Protectorate is home to 43 species belonging to 38 genera and 22 families. Chenopodiaceae has the highest contribution to the total flora (18.6%), followed by Asteraceae and Poaceae, with 5 species for each (11.6%) of the total number of recorded species. Therophytes (37%) and cryptophytes (34.87%) are the most abundant life forms. Phytogeographically, the Mediterranean (mono-, bi-, and pluriregional) chorotype is represented by the highest percentage of plant species (41.86%). Two-way indicator analysis (TWINSPAN) revealed that the vegetation is classified into four groups. Detrended correspondence analysis (DCA) confirmed the segregation of these vegetation groups, and canonical correspondence analysis (CCA) indicated that the most significant environmental variables affecting the distribution of these groups were pH, electrical conductivity, total dissolved salts, total organic carbon, total organic matter, nitrate, sodium, sulphate, magnesium, lead, zinc, phosphorus, sand and silt. In conclusion, the Egyptian Government has developed a project that began in 2017, affecting biodiversity and habitat structure.

INTRODUCTION

Wetlands are among the most eco-complex ecosystems in the world. Wetlands are regions saturated or inundated by ground or surface water either seasonally or permanently at a period enough to support a prevalence of vegetation that is typically adapted for life in saturated soil conditions. Generally, water is the main factor controlling the environment and the associated flora and fauna in wetlands. They include swamps, marshes, bogs, fen, peatland, etc.. **(Pipan & Culver, 2019)**. They have significant economic, social, and ecological importance for humans and nature. Although wetlands cover only 6–8% of the earth's surface, they are a shelter for 20 – 40% of the world's flora and fauna species, and they provide tourism opportunities **(Mitra *et al*., 2003; Gore *et al*., 2016)**. In addition, wetlands are among the most effective carbon sequestration on earth **(Bhowmik, 2022)**. Nevertheless, in the last 100 years, an alarming 50 percent of the world's wetland ecosystems have been devastated, threatening human welfare at a time of increasing water scarcity **(Matthews, 1993)**. This extensive decline in wetland ecosystems occurred in many developing countries, either directly or indirectly during the last few decades because of many challenges; natural and anthropogenic activities that are threatening the existence of the wetlands. They are vulnerable to the impacts of climate change, eutrophication, pollution, unsustainable ecotourism, overfishing and land use changes. The land use changes can be performed by reclamation of wetlands for urbanization, agriculture, and other economic purposes, over-exploitation of the wetland resources, and disturbing the biodiversity. These challenges have significant negative impacts on wetland hydrological balance, soil fertility, wildlife and biodiversity conservation, as well as ecosystem services **(Daryadel & Talaei, 2014; Horvath *et al*., 2017; Bhowmik, 2022)**.

The beginning of conservation and management of biological diversity in wetlands was the main priority for action by national governments and international conventions such as International Ramsar Convention. It is an intergovernmental treaty on wetlands, which was held in Iran (in February 1971) and provided a framework for international cooperation and national action for the conservation and sustainable use of wetlands according to **Matthews (1993)**, **Mitsch and Gosselink (2015)** and **El-Gamal (2017)**. Therefore, some of the sustainable development goals (SDGs), established in 2015 by the United Nations (UN) and Egypt (as one of the participants) aimed to minimize the rate of wetlands loss, achieve the wise use of wetlands, and conserve the biodiversity in wetlands. These are related to SDGs No. 14 (i.e., life below water) and SDGs No.15 (i.e., life on land) according to **Johnston (2016)**.

In Egypt, there are five northern wetland lakes including Deltaic lakes (Manzala, Edku, Burullus and Mariut) and non-deltaic (Bardawil) extending along the Mediterranean coast. The coastal Nile Delta lakes (Deltaic lakes) represent approximately 25% of the total wetlands' area of the Egyptian Mediterranean region **(Negm *et al*. 2018)**.

Deltatic lakes are characterized by their significant interest in biodiversity, especially for flora, birds and fish. They are significant hot spots for the Egyptian flora, particularly aquatic plants. Nearly 402 plant species (19% of the whole Egyptian flora) are characterized by 45 plant communities that prevailed in these lakes **(Shaltout *et al*. 2017)**. Additionally, these lakes are regarded as important staging, wintering, and breeding regions for water residents and migratory birds **(EEAA, 1997)**. According to the statistics of the General Authority for Wealth Development Fisheries in 2020, fish production in these lakes was about 198 thousand tons, representing 9.85% of the total fish production in Egypt **(Hamza & Amer, 2022)**.

Lake Manzala (LM) is the largest and most economically important coastal wetland of the northeastern Nile Delta lakes. LM conserves natural vegetation within various ecosystems, terrestrial, aquatic, and salt-loving ecosystems; these species are used therapeutically and economically in the country **(Abdelhamid *et al*., 2013)**. It is a productive and valuable natural fishery water body for fishing in the country **(Abdel Ghaffer, 2006; Rashad & Abdel-Azeem, 2010)** . In recent years, fish production has reached approximately 56% of the total country's yield **(GAFRD, 2014; Mansour *et al*., 2018)**. In addition, LM contains some of the historical and archaeological sites such as Tel-Tennis and Tel-Ghussein islands **(Ibrahim, 1993; Meininger & Atta, 1994)**. Moreover, it is a unique interest place for this study.

Generally, LM is environmentally unprotected under national legislation, except for the northeastern part of the lake sector at the Ashtum El-Gamil site, which is recognized as a natural protectorate called Ashtum El-Gamil Protectorate (AGP) **(Meininger & Atta, 1990)**. AGP is one of the most interesting wetland protectorates that overlooks LM **(Sector, 2006; Omar *et al*. 2017)**. Ashtum El-Gamil was declared a protectorate because it is one of the important natural special stagings for people who are interested in bird-watching activities. It represents the third international path of water-bird migration from Europe and Asia to Africa along the Mediterranean Sea **(Ayache *et al*., 2009; EEAA, 2012)**. Unfortunately, it is among the rapidly threatened habitats in Egypt because of natural and anthropogenic interferences, including climatic changes and the creation of the Port Said International Coastal Road and Port Said-Damietta Road over the last two decades **(EEAA, 2003; Rashad & Abdel-Azeem, 2010)**. Accordingly, the main objectives of this study were to assess the present situation of vegetation, determine the influence of environmental variables on vegetation distribution and address the habitat diversity in AGP.

MATERIALS AND METHODS

1. Study area

Ashtum El-Gamil Protectorate (AGP) is situated in the eastern north corner of LM. It is located between latitudes 31° 15′ N and longitudes 32° 10′ E (13 km^2 to the west of Port Said City). It includes new and old El-Gamil inlets in the north part. It is declared as a protected area by Prime Minister's decree No. 459/1988 with an area of about 30km^2; later it was modified with decree No. 2780/1998 to extend its area to about 180km^2 **(Geene *et al*., 1989; Ibrahim, 1989)**. It is bordered from north by the road Port Said-Damietta, east by Port Said-Ismailia Road, south by the Sea of Bahr El-Bashtier in

Lake, and west by a line inside LM until the Ganab El-Tamasah, passing by two seas lagan and kurumulls Sea (Fig. 1). An extensive network of islands divides AGP into interconnected basins with their different water characteristics and consequently species distribution due to the discontinuity between these basins. Most of the islands have been covered by native herbaceous plants and are surrounded by emergent vegetation that predominantly are *Phragmites australis, Typha domingensis* and *Echinochloa stagnina* **(Ayache *et al*., 2009; Bernhardt *et al*., 2011; HTC, 2018; Https://Www. Eeaa.Gov.Eg/Portals/0/EeaaReports/N Protect/Ashtom.Pdf (n.d))**.

2. Eco-climatic variables

In general, AGP is a part of the northern Mediterranean coastal land of the Nile Delta region of Egypt. According to the world map distribution of the arid regions, AGP belongs to the dry arid to the semiarid climatic region **(UNESCO, 1979)**. AGP is characterized by hot dry summers and cool wet winters, according to the Köppen classification scheme **(Kottek *et al*. 2006; Lionello, 2012)**. The meteorological data were collected from the weather station of Port Said in El-Gmail airport, Egypt during the period from 2019 to 2021. The climatic parameters of the investigated study area were: air temperature (T °C), relative humidity (RH %): rainfall (Rf mm/month) and wind velocity above the earth's surface (WV m/second). Additionally, data revealed that annual means of minimum and maximum temperatures were 18.86 and 24.85°C, respectively. The coldest winter month (January) has a mean temperature of 9.4°C, and the warmest summer month (July) has a mean temperature of 31.5°C. The air is moist all the year round so the RH is remarkably similar during the year, with an average equal to 72.74% per year. The Rf was sporadic with a total amount of 51.6 mm/year. The highest Rf was in February (42.2 mm/month), and the lowest was in April (0.2 mm/month). The WV is almost uniform throughout the year. Its values ranged between 3.5 and 4.7m/ second (**Table** (1).

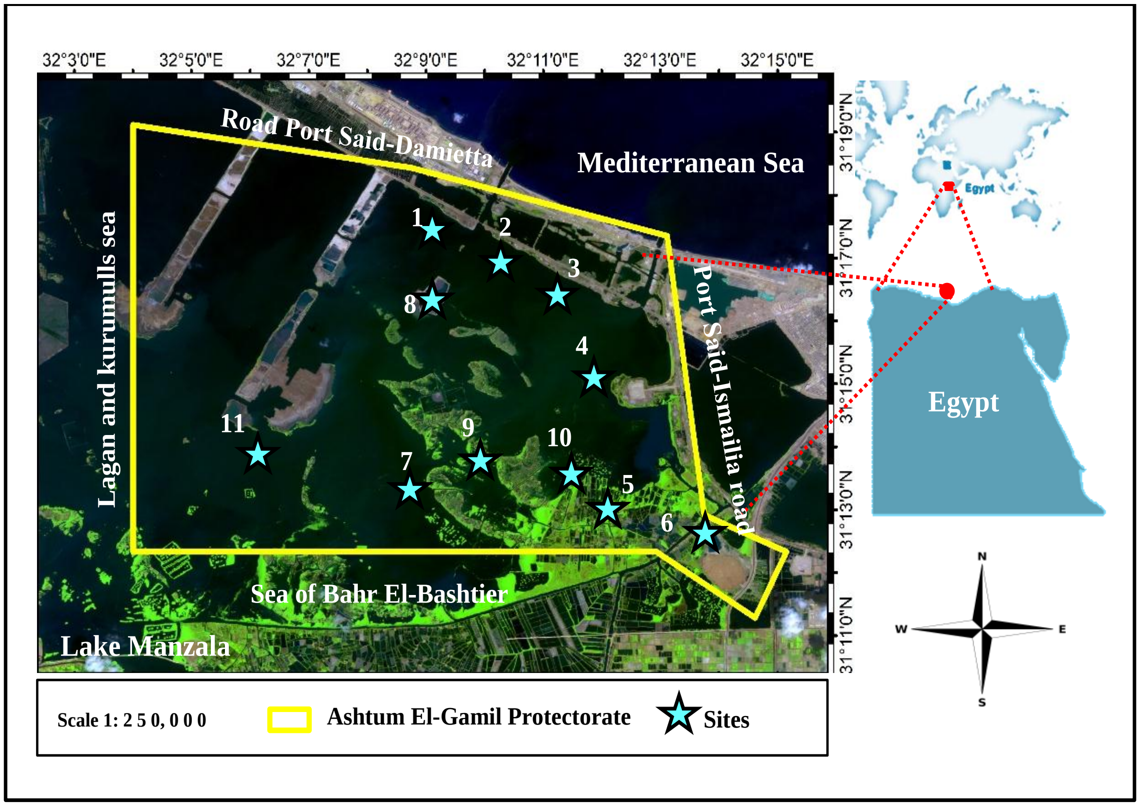

Fig. 1. Location map of Ashtum El-Gamil Protectorate using Landsat 8 at path/row (176/38) showing different sites as indicated by ( ) in the study area.

Table 1. Monthly variation in air temperature T (°C), relative humidity RH (%), rainfall Rf (mm/month), and wind velocity WV (m/s), as recorded at El-Gmail meteorological station in Port Said Airport (the highest and the lowest values are in bold).

Variables	**T (°c)**			**RH (%)**	**Rf (mm/month)**	**WV (m/s)**
Month	**T-max (°c)**	**T-min (°c)**	**T- average (°c)**			
January	**17.8**	**9.4**	13.5	**70.8**		4.3
February	18.4	12.3	15.1	73	**42.2**	3.9
March	19.7	13.2	16.1	**74.6**	1.8	**4.7**
April	21.3	15.9	18.3	72.4	**0.2**	4.3
May	26	20.3	22.8	72	—	4.1
June	29.3	23.6	26.3	**74.6**	—	3.9
July	**31.5**	**25.4**	28	72.8	—	3.9
August	31.1	**25.4**	28.3	72.9	—	**3.5**
September	30.3	24.3	27	70.9	—	3.8
October	27.8	22.6	24.8	74.4	0.8	3.9
November	25.1	20.2	22.5	71.1	2	4
December	19.9	13.7	16.8	73.4	1.3	4.5
Average	24.85	18.86	21.63	72.74	**Total** = 51.60	4.07

3. Floristic analysis

3.1. Fieldwork

The fieldwork was carried out in the period from 2019 to 2021 during several expeditions to AGP. A total of 50 stands of $25m^2$ (5×5) were randomly selected among eleven sites to represent the vegetation and their different habitats. The occurrence of each stand was georeferenced using a geographic positioning system (GPS) (Model Garmin GPSmap®76). The stratified random sampling technique was used for vegetation sampling **(Bhatta *et al*., 2012; Baxter, 2014; Swacha *et al*., 2017)**.

3.2. Vegetation analysis

Plant specimens were collected, identified, preserved on herbarium sheets, and placed in the Ecological Research Unit, Botany Department, Faculty of Science, Ain Shams University. Identification of species was made according to **Tackholm (1974)** and **Boulos (1999, 2000, 2005, 2009)**. The life forms of plant species were recorded according to **Raunkiaer (1934)**. The categories of chorotype (floristic categories) associated with the studied species were determined according to **Zohary (1973)** and **Takhtajan (1986)**.

PC-ORD version 5.0 is a program used to calculate species diversity within 50 stands using four diversity indices **(McCune & Mefford, 2006)**. The dominance of species in the study area is determined by the calculation of absolute and relative density, absolute and relative frequency, cover absolute and relative, and importance value for all stands in each group by using the equation: I.V. = R.F. + R.D. + R.C. **(Curtis & McIntosh, 1950)**.

4. Soil analysis

Fifty soil samples were collected from the studied stands; three soil samples from each stand in depth (0-25 cm) were collected. Then, these samples were combined to form one composite sample. The physicochemical properties were determined by the analysis of 21 soil variables. Soil texture was determined to provide quantitative data on the percentage of sand, silt, and clay by using the hydrometer method (wet sieving) **(Bouyoucos, 1962)**. Soil reaction (pH) was determined by an electrical pH meter (Model, 3510, Jenway, UK); the electrical conductivity (EC) was recorded by an electrical conductivity meter (Model Orion 150A+, Thermo Electron Corporation, USA); and then total dissolved salts (TDS) were estimated. All the above were determined according to **Richards *et al*. (1954)**, **Jackson (2005)** and **Rhoades (2018)**. The amounts of total organic carbon (TOC) and total organic matter (TOM) were determined according to **Richards *et al*. (1954)** and **Cummins (1962)**.

The available phosphorus (P^{3+}) was calorimetrically determined by the phosphomolybdate method using the UV/Visible Spectrophotometer (Model, Unicam UV 300, Thermo Spectronic, USA) **(Soltanpour, 1991)**. The available nitrogen [N-Nitrate ($N\text{-}NO_3^-$)] was determined by the Kjeldahl steam distillation method **(Carter & Gregorich, 2009)**. Additionally, soluble anions; bicarbonate (HCO_3^-); chloride (Cl^-) and sulphate (SO_4^{2-}), and soluble cations calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), and potassium (K^+) were determined according to the methods outlined in **Hao *et al*. (2007)**. Furthermore, the sodium adsorption ratio (SAR) was calculated applying the equation used in the study of **Reeve *et al*. (1954)**:

$$SAR = \frac{Na^+}{\sqrt{0.5\,(Ca^{2+} + Mg^{2+})}}$$

5. Statistical analysis

5.1. Multivariate analysis of vegetation and soil samples

Floristic data were exposed to an analysis by a series of multivariate analysis techniques to determine and separate vegetation groups. The determination of vegetation groups was estimated using the two-way indicator species analysis (TWINSPAN) **(Hill, 1997)**, while their separation was determined by detrended correspondence analysis (DCA) or DECORANA techniques **(Hill & Gauch, 1980)**, using PC-ORD version 5.0 **(McCune & Mefford, 2006)**. Canonical correspondence analysis (CCA) was used to reveal the relationship between environmental variables and vegetation via CANOCO version 4.5 **(Braak, 1988)** and CanoDraw version 4.14 **(ter Braak & Smilauer, 2002)**.

5.2. Pearson correlation coefficient (r)

The program SPSS version 18 was used to calculate the correlation coefficient of environmental factors to test the significant differences among soil variables **(Cronk, 2020)**.

RESULTS

1. Floristic analysis

1.1. Floristic list

Floristic analysis of AGP revealed that it is home to 43 species, belonging to 38 genera and 22 families, including 16 annuals (37.2%) and 27 perennials (62.7%). These species are categorized into 28 terrestrial and 15 aquatic species (i.e., 8 emergent, 5 free-floating and 2 submerged). Chenopodiaceae has the highest contribution to the total number of the recorded species (comprising 8 species-18.6%), followed by Asteraceae and Poaceae, with 5 species for each (11.6%) of the total number of the recorded species. These three families constitute most of the flora in AGP (Table (**2**).

1.2. Life forms

According to the life-form scheme of **Raunkaier (1934)**, there are five life-form spectra in AGP. Therophytes (Th) have the highest contribution, represented by 16 species (37% of the total species). It is followed by Cryptophyte (Cr) (34.87%), Chamaephytes (Ch) (18.60%), Phanerophytes (Ph) (6.97%) and Hemicryptophytes (H) (2.32%) (Table (**2** & Fig. 2).

1.3. Chorotype

Considering the global phytogeographical regions, the recorded species are grouped under five major floristic categories: monoregional, bioregional, pluriregional, pantropical and cosmopolitan. Monoregional contained 8 species (18.60%); while, Sudano-Zambesian (SU-ZA) represented the highest number of records among all the monoregional classes, with 3 species. The bioregional category contained (9 species - 20.9%); Mediterranean+Saharo-Sindian (ME+SA-SI) represented the highest number of records among all the bioregional classes as it scored 3 species. Pluriregional category contained 11 species (25.5%); the Mediterranean plus Irano-Turanian and Saharo-Sindian (ME+IR-TR+SA-SI) represented the highest number of records among all the pluriregional classes as it scored 3 species (6.9%). The Mediterranean (mono-, bi- and pluriregional) chorotype constituted the largest group (18 species - 41.68 % of the total flora) with variations in their life forms in this study. Pantropical (PAN) represented the lowest number of records among the five categories as it scored 1 species (2.3%). While, Cosmopolitan chorotype attained the highest number of species records among the five categories of chorotype; it contained 14 species (32.2%) of the total number of the recorded species (Table (**2** & Fig. 2).

Table 2. Checklist of the recorded plant species in AGP with their families, vernacular names, number of species and percentage of existence, duration, habitats, life forms (LF) and chorotype (Ch).

Family	Species	Vernacular name	No. of species and % of existence	Duration	Habitats	LF	Ch
Asteraceae	*Calendula arvensis* L.	عِين الصَفْرا- عين القُط	5 (11.60%)	Annual	Terrestrial	Th	EM
	Limbarda crithmoides (L.).Dumort.	حَطَبْ زِيتى		Perennial	Terrestrial	Ch	ME+ER-SR+SA-SR
	Pluchea dioscoridis (L.) DC.	بَرْنُوفْ		Perennial	Terrestrial	Ph	SU-ZA+SA-SI
	Senecio flavus (Decne.) Sch.Bip.	ام الوينين		Annual	Terrestrial	Th	SA
	Soncuhs oleraceous L.	جُعضيض		Annual	Terrestrial	Th	COSM
Aizoaceae	*Mesembryanthemum crystallinum* L.	غَسُول	3 (6.90%)	Annual	Terrestrial	Th	ME+ER-SR
	Mesembryanthemum forsskaolii Hochst. ex Boiss.	حَمْد (نبات الثلج)		Annual	Terrestrial	Th	SA-SI
	Mesembryanthemum nodiflorum L.	سَمْح		Annual	Terrestrial	Th	ME+ER-SR+IR-TR
Asclepiadaceae	*Cynanchum acutum* L.	عُلّيق	1 (2.30%)	Perennial	Terrestrial	Ph	ME+IR-TR
Araceae	*Pistia stratiotes* L.	لُقمة القاضي	1 (2.30%)	Perennial	Free-floating	Cr (Hy)	PAN
Brassicaceae	*Cakile maritima* Scop.	رَشَاد البحر	1 (2.30%)	Annual	Terrestrial	Th	ME+ER-SR
Boraginaceae	*Heliotropium curassavicum* L.	غبيرة	1 (2.30%)	Perennial	Terrestrial	Ch	COSM
Ceratophyllaceae	*Ceratophyllum demersum* L.	نَخشوش الحوت	1 (2.30%)	Perennial	Submerged	Cr (Hy)	COSM
Chenopodiaceae	*Arthrocnemum macrostachyum (Moric.) K. Koch.*	شِنان	8 (18.60%)	Perennial	Terrestrial	Ch	ME+SA-SI
	Atriplex portulacoides L.	قَطَف- قطْف		Perennial	Terrestrial	Ch	ME+ ER-SR +IR-TR
	Bassia arabica (Boiss.) Maire&Weiller.	قضقاض عربي		Perennial	Terrestrial	Ch	SA
	Chenopodium murale L.	لِسان الطير(الثور)		Annual	Terrestrial	Th	COSM
	Chenopodium album L.	رُقاب الجمل		Annual	Terrestrial	Th	COSM
	Chenopodium ambrosioides L.	زربيح		Annual	Emergent	Th	COSM
	Halocnemum strobilaceum (Pall.) M. Bieb.	حطب حدادي		Perennial	Terrestrial	Cr (Ge)	ME+IR-TR+SA-SI
	Suaeda maritima (L.) Dumort.	سويداء بحرية		Annual	Terrestrial	Ch	COSM

Table 3. Continued

Family	Species	Vernacular name	No. of species and % of existence	Duration	Habitats	LF	Ch
Cyperaceae	*Cyperus conglomeratus* Rottb.	السِعْد - سِعْد	2 (4.70%)	Perennial	Terrestrial	Cr (Ge)	SU-ZA +SA-SI
	Cyperus laevigatus L.	بُربيط - بُرْعَن		Perennial	Emergent	Cr (Ge)	ME+SA+ IT
Juncaceae	*Juncus rigidus* Desf.	سَمار مُرّ	2 (4.70%)	Perennial	Emergent	Cr (Ge)	ME+IR-TR +SA-SI
	Juncus subulatus Forssk.	سَمار حلو		Perennial	Emergent	Cr (Ge)	ME+IR-TR+SA-SR
Lemnaceae	*Lemna gibba* L.	عَدْس الميه	2 (4.70%)	Perennial	Free-floating	Cr (Hy)	COSM
	Spirodela polyrhiza (L.) Schleid.	عَدْس الميه		Perennial	Free-floating	Cr (Hy)	COSM
Malvaceae	*Malva parviflora* L.	خبيزة	1 (2.30%)	Annual	Terrestrial	Th	ME+IR-TR
Onagraceae	*Ludwigia stolonifera* (Guill & Perr.) P. H. Raven.	فُرْقَاع	1 (2.30%)	Perennial	Free-floating	Cr (He)	SU – ZA
Poaceae	*Echinochloa stagnina* (Retz.) P.Beauv.	نسيلة	5 (11.60%)	Perennial	Emergent	Cr (Ge)	SU-ZA
	Eragostis aegyptiaca (Willd) Delile.	أثب مصري		Annual	Terrestrial	Th	SU-ZA
	Imperata cylindrica (L.) Raeusch.	حلفا		Perennial	Terrestrial	H	ME+ IR-TR+SA-SI
	Phragmites australis (Cav.) Trin.ex Steud.	حَجْنة- غاب- بوص		Perennial	Emergent	Cr (Ge)	COSM
	Polypogon monspeliensis (L.) Desf.	ديل (ذيل) القط		Annual	Terrestrial	Th	COSM
Pontderiaceae	*Eichhornea crassipes* (C.Mart.) Solms.	ورد النيل	1 (2.30%)	Perennial	Free-floating	Cr (Hy)	COSM
Potamogetonaceae	*Potamogeton pectinatus* L.	عَلَاق	1 (2.30%)	Perennial	Submerged	Cr (Hy)	COSM

Table 4. Continued

Family	Species	Vernacular name	No. of species and % of existence	Duration	Habitats	L.F	Ch
Polygonaceae	*Emex spinosa* (L.) Campd.	رُكبة العجوز	1 (2.30%)	Annual	Terrestrial	Th	ME+SA-SI
Ranunculaceae	*Ranunculus sceleratus* L.	زَغلنته	(2.30%)1	Annual	Emergent	Th	ME+ER-SR +IR-TR
Solanaceae	*Solanum nigrum* L.	عَنب (عِنب) الديب	1 (2.30%)	Annual	Terrestrial	Th	COSM
Typhaceae	*Typha domingensis* (Pers.) Poir.ex Steud.	بُردى-بَرْدى-بِرْدى	1 (2.30%)	Perennial	Emergent	Cr (Ge)	ME+IR-TR + SA-SI
Tamaricaceae	*Tamarix aphylla* (L.) H. Karst.	أتل-أثل-إتل	1 (2.30%)	Perennial	Terrestrial	Ph	SA+SZ+IT
Zygophyllaceae	*Zygophylum album* L.f.	رَطريت-رُطريت	2 (4.70%)	Perennial	Terrestrial	Ch	ME+SA-SI
	Zygophyllum decumbens Delile.	خِريزة		Perennial	Terrestrial	Ch	SA-SI

Life Forms (L.F.): Th: Therophytes, Ch: Chamaephytes, Cr: Cryptophyte; Ge: Geophytes, He: Helophyte, Hy: Hydrophyte, Ph: Phanerophytes and H: Hemicryptophytes. **Chorotype (Ch):** SA: Saharo Arabian, SU-ZA: Sudano-Zambesian, EM: Euri-Mediterranean, ME: Mediterranean, SA-SI: Saharo-Sindian, IR-TR: Irano-Turanian, ER-SR: Euro-Siberian, IT: Irano–Turanian, SA-SR: Saharo-Siberian, COSM: Cosmopolitan and PAN: Pantropical.

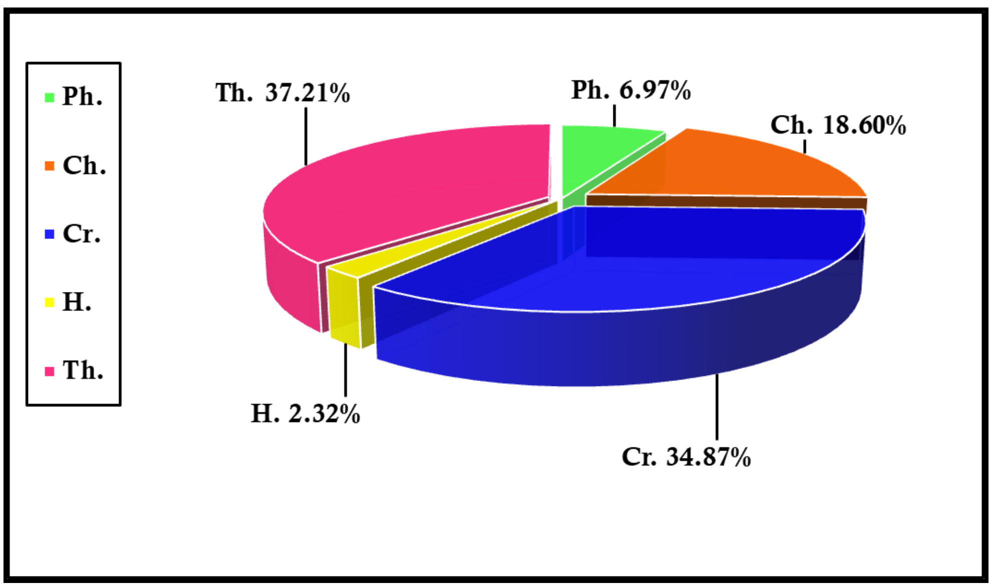

Fig. 2. Life form spectrum of the total recorded species in AGP

Th: Therophytes, Cr: Cryptophyte, Ch: Chamaephytes, Ph: phanerophytes, and H: Hemicryptophytes.

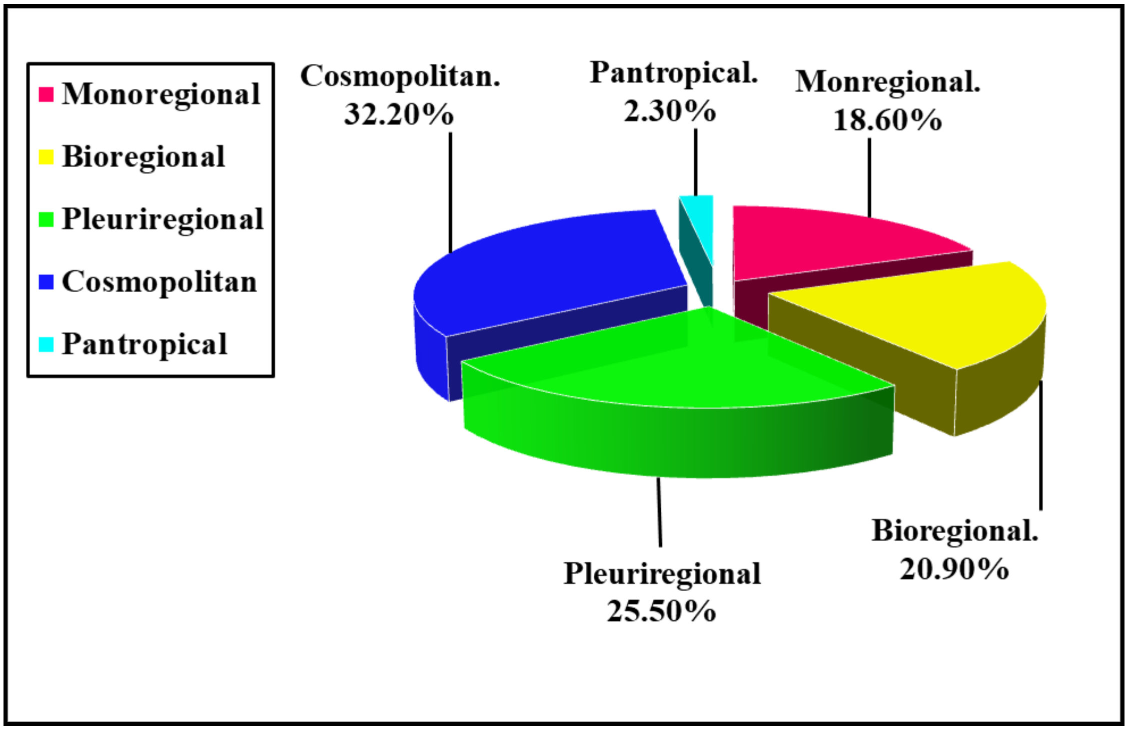

Fig. 3. Floristic categories spectrum of the total recorded species in AGP

2. Soil analysis

The results of the soil analysis (as in supplementary Tables 1, 2 and 3) reveal that the soil texture of the fifty stands studied varied between sandy in the north and loamy sand soil in the south. The fraction of sand was predominant at all studied stands, and its percentage ranged from 86.07% to 98.37%. The soil pH was slightly alkaline for all studied stands. It ranged from 7.77 to 9.88 within the different samples. The values of EC in the studied soil samples ranged from 0.59 to 42.88 (µS/cm), while TDS ranged from 377.6 to 27445.33 ppm. The values of TOC ranged from 0.03% to 3.12%, and TOM ranged from 0.05% to 5.37%. AGP is characterized by the high concentration of available nutrients (NO_3^- and P^{3+}). The nitrate content (NO_3^-) ranged from 3.37 to 699 ppm, and the phosphorus content (P^{3+}) ranged from 4.2 to 46.43 ppm. Results show that some salinity factors, such as anions (HCO_3^-, Cl^-, and SO_4^{2-}) and cations (Ca^{2+}, Mg^{2+}, Na^+, and K^+) showed high concentrations among the different stands. The sodium adsorption ratio (SAR) value of the samples is high and ranged between 0.02 and 39.39meq/ L.

3. Statistical analysis

3.1. Pearson correlation coefficient (r)

The correlation coefficient (r) in the study stands between various soil variables that provide the growth of plant species. It revealed that EC and TDS are strongly correlated with NO_3^-, Pb^{2+}, TOC, TOM, cations (Ca^{2+}, Mg^{2+}, Na^+, and K^+), some anions (SO_4^{2-} and Cl^-) and silt. They show high positive significance with EC and TDS at 0.01, which indicates that as soon as they increase, the EC and TDS will increase. However, EC and TDS are strongly negatively correlated with Fe^{2+} and sand at 0.01, which indicates that as soon as they increase, the EC and TDS decrease. Additionally, NO_3^- is correlated with sand and P^{3+}. They showed negative significance with NO_3^- at 0.01 and 0.05. While, Zn^{2+} is correlated with Pb^{2+}. It shows positive significance with Zn^{2+} at 0.05; this indicates that as soon as it increases, Zn^{2+} increases. TOC and TOM contents are positively correlated with silt contents, soluble anions (HCO_3^-, SO_4^{2-}, and Cl^-) and soluble cations (Ca^{2+}, Mg^{2+}, Na^+, and K^+); this indicates that as soon as they increase, TOC and TOM contents also increase. Soluble cations (Ca^{2+}, Mg^{2+}, Na^+, and K^+) are positively correlated with S, silt contents, and some soluble anions (SO_4^{2-} and Cl^-), indicating that as soon as they increase, the soluble cation contents increase. The sand fraction is strongly correlated with other soil fractions (silt and clay): these fractions showed negative high significance at P = 0.01 with sand. While, the diversity indices (H, D, E, and S) are strongly positively correlated with each other; this shows a positive significance at *P*= 0.01. However, clay and HCO_3^- do not correlate with any of the other soil variables, as in the supplementary data in Table (4).

3.2. Multivariate analysis of vegetation and soil samples

3.2.1. TWINSPAN classification. TWINSPAN classification has divided the vegetation that grows naturally in the 50 stands of AGP into four vegetation groups at the 3rd level of classification. Each sample group included a set of stands with more vegetation homogeneity than the other sample groups. Each group is characterized by indicator species, identified by TWINSPAN for each group at each level of hierarchical classification (Fig. 4 & Table (**53**). The application of DCA or DECORANA to the same data revealed a well-defined separation of the vegetation groups into 4 groups along axis 1 and axis 2 of DCA. These 4 groups were separated into 2 clusters: islands (G1 and G2) and borders (G3 and G4) along the DCA ordination plane of axis 1 and 2 (Fig. 5). The vegetation groups are named after the recognition of the dominant species. These species have the highest importance value (I.V.) as follows:

Group (1). *Eichhornea crassipes*: This group comprises 3 species and is indicated by *Calendula arvensis*, *Eichhornea crassipes*, *Typha domingensis* and *Zygophyllum album.* The leading dominant species of this group is *Eichhornea crassipes* (I.V. = 47.63).

Group (2). *Phragmites australis:* This group comprises 26 stands and is indicated by *Calendula arvensis*, *Eichhornea crassipes*, *juncus rigidus*, *Phragmites australis*, *Ranunculus sceleratus* and *Typha domingensis*. The leading dominant species of this group is *Phragmites australis* (I.V. = 69.46).

Group (3). *Arthrocnemum macrostachyum*: This group comprises 15 stands and is indicated by *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum* and *Mesembryanthemum crystallinum.* The leading dominant species of this group is *Arthrocnemum macrostachyum* (I.V. = 78.47).

Group (4). *Mesembryanthemum crystallinum*: This group comprises 6 stands and is indicated by *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum*, *Malva parviflora*, *Mesembryanthemum crystallinum* and *Mesembryanthemum nodiflorum.* The leading dominant species of this group is *Mesembryanthemum crystallinum* (I.V. = 52.95).

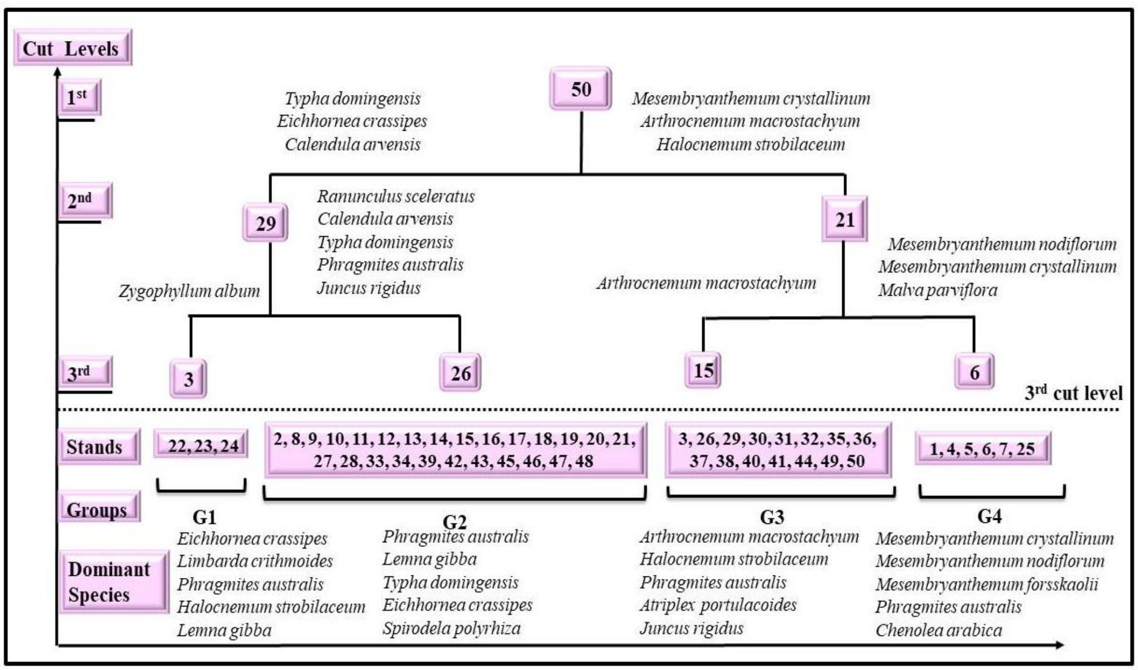

Fig. 4. TWINSPAN dendrogram of the 50 stands of 43 species in AGP. Indicator species for each group were listed.

Table 5. Importance value (I.V.) for the dominant species of four TWINSPAN vegetation groups (G1, G2, G3 and G4) in AGP

Group	Indicator species	Dominant species	I.V.
G1 n=3	*Typha domingensis*	*Eichhornea crassipes*	47.63
	Eichhornia crassipes	*Limbarda crithmoides*	46.84
	Calendula arvensis	*Phragmites australis*	46.04
	Zygophyllum album	*Halocnemum strobilaceum*	31.55
		Lemna gibba	19.19
G2 n=26	*Ranunculus sceleratus*	*Phragmites australis*	69.46
	Calendula arvensis	*Lemna gibba*	36.95
	Typha domingensis	*Typha domingensis*	36.62
	Phragmites australis	*Eichhornea crassipes*	30.09
	Juncus rigidus	*Spirodela polyrhiza*	14.37
G3 n=15	*Mesembryanthemum crystallinum*	*Arthrocnemum macrostachyum*	78.47
	Arthrocnemum macrostachyum	*Halocnemum strobilaceum*	74.02
	Halocnemum strobilaceum	*Phragmites australis*	41.93
		Atriplex portulacoides	20.09
		Juncus rigidus	13.64
G4 n=6	*Mesembryanthemum crystallinum*	*Mesembryanthemum crystallinum*	52.95
	Arthrocnemum macrostachyum	*Mesembryanthemum nodiflorum*	38.66
	Halocnemum strobilaceum	*Mesembryanthemum forsskaolii*	38.63
	Mesembryanthemum nodiflorum	*Phragmites australis*	24.61
	Malva parviflora	*Bassia arabica*	21.22

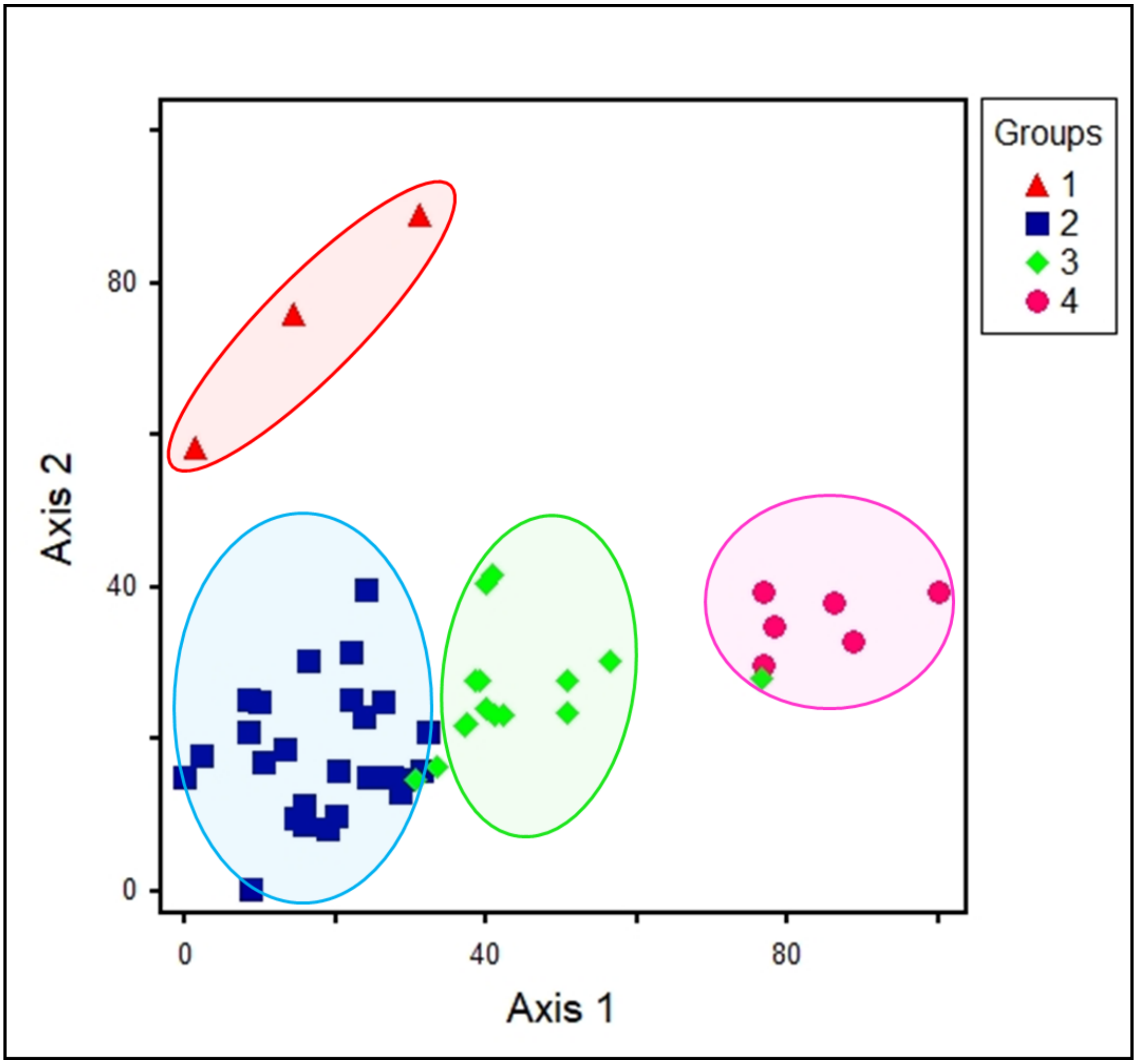

Fig. 5. DCA ordination diagram on axes 1 and 2 of the 50 stands in AGP

3.2.2. Canonical Correspondence Analysis (CCA) Ordination. A biplot of the stands of vegetation groups and environmental variables along AGP was examined by using the CCA ordination program. The arrows representing 21 environmental variables and 4 biodiversity indices are in association with the 4 vegetation groups of TWINSPAN. The length of the arrow is directly proportional to the rate of variation in this direction; the environmental variables with short arrows are less correlated with the ordination than those of long arrows, and the direction of the arrows represents the direction of the environmental variable within the samples measured. It indicated that the most significant soil variables controlling the distribution and abundance of the plant communities in AGP are pH, EC, TDS, NO_3^-, P^{3+}, Na^+, Cl^-, TOC, TOM, Zn^{2+}, Mg^{2+}, SO_4^{2-}, sand and silt. The soil physicochemical factors in group 1 showed the highest values of NO_3^-, P^{3+} and Fe^{2+} and the lowest values of pH, EC, TDS, Ca^{2+}, Mg^{2+}, Na^+, K^+, HCO_3^-, Cl^-, SO_4^{2-}, clay and diversity indices. While, the mean soil physicochemical factors in group 2 showed the highest values of EC, TDS, Cd^{2+}, TOC, TOM, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, silt and clay content in addition to the lowest value of P^{3+}. Moreover, the mean soil physicochemical factors in group 3 showed the highest values of Zn^{2+}, Pb^{2+}, HCO_3^- and sand content, as well as the lowest value of silt. While, the mean soil physicochemical factors in group 4 showed the highest values of pH, species diversity indices, and Cd^{2+} content in addition to the lowest values of NO_3^-, Zn^{2+}, Pb^{2+}, Fe^{2+}, TOC, TOM and sand (Table (64 & Fig. 6).

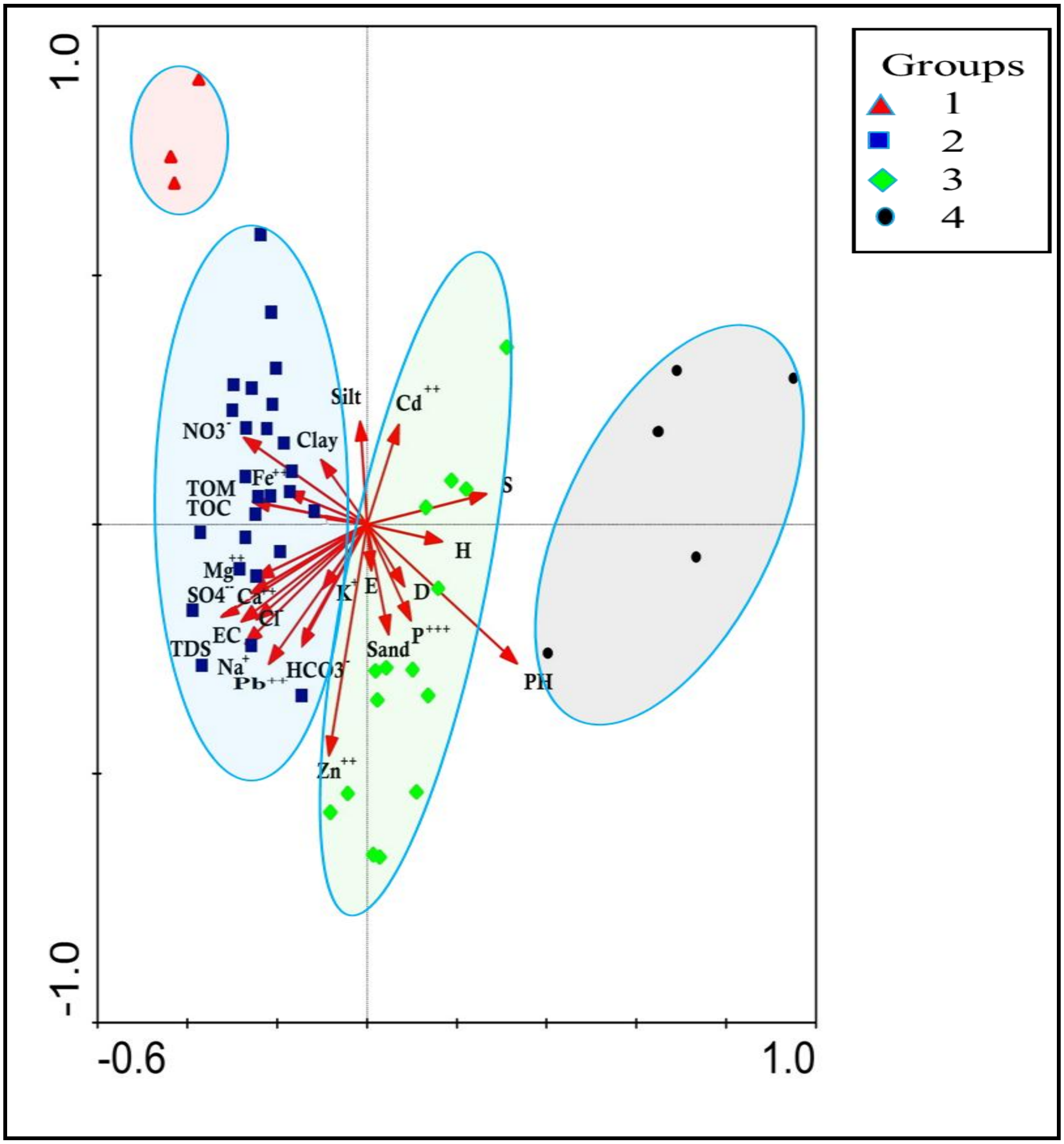

Fig. 6. CCA biplot of the first two axes showing the ordination of the four vegetation groups in response to different environmental variables (arrows) in AGP

Table 6. Mean ± standard deviation of 21 soil variables and four biodiversity indices in the sampling stands representing the four vegetation groups (G1, G2, G3, and G4), obtained by TWINSPAN classification of AGP

Variables	G1	G2	G3	G4
Number of stands	**3**	**26**	**15**	**6**
pH	7.99 ±0.08	8.2 ±0.29	8.3 ±0.26	8.73 ±0.61
EC (µS/cm)	5.63 ±0.64	15.45 ±11.61	11.58 ±9.75	6.86 ±4.37
TDS (ppm)	3602.84 ±411.77	9887.75 ±7432.83	7412.34 ±6239.28	4391.82 ±2795.19
NO_3^- (ppm)	144.18 ±52.71	126.84 ±140.08	41.86 ±56.44	35.68 ±16.04
P^{3+} (ppm)	25.63 ±14.74	15.35 ±8.99	20.04 ±9.43	16.04 ±7.69
Zn^{2+} (mg/kg)	1.59 ±0.5	4.11 ±6.78	5.71 ±9.4	1.35 ±0.73
Cd^{2+} (mg/kg)	0.01 ±0.01	0.02 ±0.03	0.01 ±0.01	0.02 ±0.02
Pb^{2+}(mg/kg)	1.66 ±1.04	3.7 ±7.08	3.99 ±6.51	1.36 ±1.72
Fe^{2+} (mg/kg)	30.57 ±7.42	17.55 ±13.32	15.93 ±9.65	15.34 ±7.78
TOC (%)	1.11 ±0.33	1.28 ±1	0.88 ±0.75	0.63 ±0.3
TOM (%)	1.91 ±0.57	2.2 ±1.71	1.51 ±1.3	1.09 ±0.51
Ca^{2+} (meq./L)	22.42 ±1.67	46.14 ±36.72	31.25 ±22.45	24.17 ±17.33
Mg^{2+} (meq./L)	16.47 ±1.48	50.45 ±36.93	33.08 ±43.77	21.32 ±20.84
Na^+ (meq./L)	21.46 ±10.45	99.25 ±92.02	79.46 ±76.97	34.01 ±33.31
K^+ (meq./L)	2.27 ±0.65	4.03 ±2.99	3.08 ±2.35	3.02 ±3.15
HCO_3^- (meq./L)	1.37 ±0.01	1.73 ±0.64	1.74 ±0.7	1.61 ±0.82
Cl^- (meq./L)	31.44 ±9.73	133.17 ±125.13	92.62 ±106.45	48.63 ±30.69
SO_4^{2-}(meq./L)	29.51 ±5.29	64.48 ±41.11	52.01 ±38.27	32.01 ±27.38
Sand (%)	94.7 ±0.85	92.28 ±3.36	95.13 ±2.41	93.18 ±2.38
Silt (%)	2.43 ±0.58	4.07 ±2.84	1.91 ±1.92	3.88 ±1.84
Clay (%)	2.87 ±0.28	3.65 ±1.32	2.96 ±1	2.94 ±0.9
Species Richness (S)	3 ±0	6.31 ±2.1	4.6 ±1.99	8 ±3.74
Species Evenness (E)	0.76 ±0.17	0.84 ±0.11	0.83 ±0.24	0.85 ±0.07
Shannon's diversity (H)	0.84 ±0.19	1.51 ±0.35	1.26 ±0.49	1.67 ±0.45
Simpson's diversity (D)	0.5 ±0.12	0.72 ±0.12	0.65 ±0.22	0.74 ±0.11

4. Habitats

Upon applying TWINSPAN classification and CCA ordination techniques, it was shown that AGP is an ideal wetland habitat, following the habitat scheming for Egypt **(Harhash *et al*. 2015)**. This wetland habitat can be distinguished into two main sub-systems. Those main sub-systems are marine wetlands (classes: rocky shoreline wetlands, sandy shoreline wetlands, and salt marsh wetlands) and fresh wetlands (class: reed swamp wetlands). Each of them was important in determining the distribution of species in the study area. The first group has sandy shoreline wetlands habitats; the habitat feature is fresh ground. While, the second group has a reed swamp wetlands habitat; the habitat feature is fresh ground. However, the third group has habitats in salt marshes; the habitat feature is saline ground. Finally, the fourth group has rocky shoreline wetlands habitat, and the habitat feature is saline ground. The highest number of species (26) was recorded in fresh wetlands habitats and represents about (60.46%) of the total recorded species, while the marine wetlands habitat was represented by 17 species (39.53%).

DISCUSSION

Data obtained from the study area along the AGP revealed that it includes forty-three species. The vascular plants recorded in LM were 144 species, belonging to 107 genera and 47 families including 77 species in AGP **(Shaltout & Galal, 2007)** and **(Https://Www.Eeaa.Gov.Eg/Portals/0/EeaaReports/N Protect/Ashtom.Pdf (n.d)).** Moreover, there is an obvious reduction in the studied recorded plant species due to the exposure of AGP to the loss of unique wetland habitats and biodiversity. These might be returned to removing many vegetated islands with their flora because of natural and anthropogenic interference including climatic changes, the construction of roads along the north coast, and touristic development during the last few years **(Ramadan, 2002; EEAA, 2003; Shaltout & Khalil, 2005)**.

In this context, Chenopodiaceae, Asteraceae, and Poaceae are considered the major families in AGP. The dominance of Chenopodiaceae might be attributed to comprising a broad variety of life forms growing in dry, hot, and saline environments in addition to coastal, tropical and humid temperate regions. Moreover, its dominance is due to containing many small seeds that spread and germinate rapidly. This rapid germination is related to the following points: 1. Their species are characterized by a short-lived cycle, which forms a soil seed bank to lessen the influence of environmental variability. 2. Their adaptation to stressful habitat conditions. 3. Most of their species are C4 plants, which are dense in hot and dry climates and saline habitats **(Kadereit *et al*. 2012)**. These results are contrary to those of **Shaltout *et al*. (2017)** who reported that, Poaceae had the highest contribution to its flora, followed by Asteraceae and Chenopodiaceae families in some Nile Delta habitats.

The abundance of perennial plants could be related to the storage of lake water in deep soil and subsoil, which may continuously provide moisture to the deep roots of perennial plants. In addition, perennial herbs may also be present in certain neglected regions where the soil is affected by salinity (with halophytes) or is swampy (with helophytes) **(Zahran & Willis, 2009)**. Although the number of terrestrial species is higher than that of the aquatic species, aquatic plants are more dominant than terrestrial ones. These findings of habitat diversity in the present study agree with those obtained by **El-Ameir and Shawky (2017)**. The high contribution of therophytes in such studies may be related to their ability to set seeds without the need for a visiting pollinator **(Baker, 1991)**. This finding is consistent with those of **Khedr and Zahran (1999)**, **Ahmed (2003)** and **Mashaly *et al*. (2008)** who described the Mediterranean climate type as a "therophyte climate". On the other hand, **Mashaly *et al*. (2013)** stated that, cryptophytes have the highest contribution in the northern lakes, followed by therophytes. The Mediterranean (mono-, bi-, and pluriregional) chorotype constitutes the largest group (18 species - 41.68 % of the total flora), with variations in their life forms as found in this study due to the location of the AGP on the northern Mediterranean Sea Coast, where the Mediterranean class increased northward **(Hegazy & Amer, 2002)**. These results coincide with those of **Maswada and Elzaawely (2013)**.

Soil texture varies between sandy and loamy sand. This might be explained by the several types of deposits, such as marine sand in the north and Nile-silt deposits in the south **(Elnaggar & El-Alfy, 2016)**. This agrees with the finding of **Zahran *et al*. (1989)**. The wide range of pH is above 7.0 in the studied stands due to photosynthetic activity or increased HCO_3^- content **(Barko *et al*., 1991)**. This measurement agrees with that of **Sallam and Elsayed (2018)**. EC of soil samples revealed that the lake is brackish due to the entrance of marine water from the Mediterranean Sea and freshwater from the drains. This trend concurs with that of previous studies (**Fishar, 1999; Sallam & Elsayed, 2018)**.

The high concentration of TDS in the study area is due to the influence of the Mediterranean Sea. This result matches with that of **Ismail and Hettiarachchi (2017)**, who mentioned that the concentration of TDS is up to 43406 ppm in LM. The highest concentrations of TOC in the present study were formed near the mouths of drains and fish farms, which might be attributed to the absorption of contaminants from sewage drains and the accumulation of plant litter **(Du Laing *et al*., 2006; El-Serehy *et al*., 2012; Kaiser *et al*., 2012)**. While, the percentage of TOC is related to the total plant cover of the communities, the lowest characterizes the soils with sparse vegetation, whereas the highest characterizes the soils with dense vegetation **(Zahran *et al*., 1989)**. This result is compatible with the study of **Elnaggar and El-Alfy (2016)**.

The highest concentrations of available nitrogen and phosphorus are present in the southern part of AGP due to domestic and agricultural wastes from the drains and a biological treatment project near Port Said City. In contrast, the lower values were found in the soils of the lake's northwestern parts, which are far from drains **(Elnaggar & El-Alfy, 2016)**. These results are compatible with the study of **El-Ameir and Shawky (2017)**. However, this is contrary to the finding of **Elnaggar and El-Alfy (2016)**. In the present study, the anions (HCO_3^-, Cl^- and SO_4^{2-}) and cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+)

revealed high concentrations. It can be deduced that, the high concentration of Ca^{2+} is attributed to the accumulation of excessive amounts of shell debris mixed with the soils detected in the northern regions and on lake islands **(Elnaggar & El-Alfy, 2016**). In this respect, the higher values of SAR have led to increased dispersion of clay particles and organic matter, degradation of soil structure, reduction of aeration and saturated hydraulic conductivity. The soil became unsatisfactory for all the vegetation and finally led to the loss of vegetation **(USDA, 2017)**.

In the present study, the TWINSPAN classification divided vegetation stands into four vegetation groups. This separation into 4 groups in TWINSPAN and DCA may be attributed to the drying process and variations in soil characteristics such as changes in salinity that affected the vegetation, and this indicates very heterogeneous environments of vegetation structure and species potentially in LM according to **Shaltout *et al*. (2005)**, **Mashaly *et al*. (2008)** and **El-Ameir and Shawky (2017)**. However, this result is contrary to that of **Ramadan (2002)** and **Zahran (2010)** whose postulated that, the classification and ordination of vegetation stands using TWINSPAN and DCA techniques led to the identification of some vegetation groups that ranged from 5 to 8 groups; however, only 2 of them are similar vegetation groups in the studied stands. This is attributed to the increasing number of plant species in LM and AGP, according to **Shaltout and Galal (2007)**. The recognized vegetation groups in the deltaic Mediterranean coastal habitat including LM, can be categorized into three classes: *Echinopetea, Arthrocnemetea,* and *Phragmetetea* according to Braun-Blanquet's floristic association system **(Braun-Blanquet, 1933)**, which agrees with the present investigation.

Results of the studied area showed that there were some changes in the recorded plant species, which might result from human impacts that consequently affect the aquatic flora **(Vermaat & De Bruyne, 1993)**. In the current study, some species that are restricted and predominated in fresh and slightly brackish regions (e.g., *Lemna gibba, Phragmites australis, Typha domingensis,* and *Eichhornia crassipes*) may be attributed to a decrease in moisture and salinity in the southern part of the AGP according to **Shaltout and Galal (2006)** and **Shaltout and Ahmed (2010)**. The southern part is provided by freshwater from the Damietta branch of the River Nile, drains (e.g., Bahr E1-Bakar, Hadous, Ramsis, etc..), canals as well as the neighboring cultivated lands that provide lake water by drainage along the western and southern shores. This led to high eutrophication as well as flourishing vegetation in reed beds **(Zalat & Saleh, 2018)**. This context coincides with those of **Dale and Miller (1978)**, **Dowidar and Abdel-Moati (1983)**, **Zahran (1992)**, **Räike *et al*. (2003)**, **Zahran and Willis (2008)** and **Zahran (2010)**.

The dominance of *Arthrocnemum macrostachyum* and *Mesembryanthemum crystallinum* in this study is due to the increase in salinity enhancement. This agrees with the results obtained by **Zahran (1992)**, **Shaltout and Galal (2006)**, **Zahran and Willis (2009)** and **Shaltout and Ahmed (2010)**. They stated that, *Arthrocnemum macrostachyum* and *Mesembryanthemum crystallinum* are common succulent halophytes, representing a prominent feature of the vegetation of islands in Lake. They grow in patches covering the high, sandy habitat in middle-low areas, where seeping water accumulates. However, there are some species with a wide ecological tolerance range that occur in all parts of the AGP, such as *Phragmites australis* and *Potamogeton pectinatus*. This result is accommodated by **Kadono (2015)** who stated that, the occurrence of aquatic plants (macrophytes) in AGP is related to a wide range of pH, alkalinity values above 7.0, EC, Cl^- and Ca^{2+} due to photosynthetic activity.

The present results revealed that the distribution of vegetation types is more strongly correlated with chemical factors in the soil than physical ones. Of all environmental variables, pH, EC, TDS, NO_3^-, P^{3+}, Na^+, Cl^-, TOC, TOM, Zn^{2+}, sand, and silt appear to be the crucial factors affecting the distribution of plant communities in AGP. This may agree with the result obtained in the studies of **Li *et al*. (2017)** and **Rahman *et al*. (2022)** who pointed out that environmental variables play a significant role in the distribution of plant communities.

The nutrient concentrations varied widely in various parts of the AGP. Such variations were mostly recorded as ecological features of the dominant plant communities recorded in AGP. NO_3^- and P^{3+} appear to be the principal environmental factors affecting the distribution of plant communities in AGP. Phosphorus is remarkably a vital nutrient for ecosystems, especially macrophyte growth, and its excess in wastewater lakes leads to some environmental problems such as eutrophication, which led to extensive algae growth. Macrophytes can uptake and consume phosphorus, and this may determine the success of these species and consequently the nature of plant communities **(Carignan & Kalff, 1980; Rezania *et al*. 2021)**. In addition, the overgrowth of macrophytes in lakes is related to the highest rate of nitrogen (nitrate- N) in soil **(Kadono, 2015)**. The habitats of recorded plant species revealed that AGP is an ideal wetland habitat after the application of both TWINSPAN classification and CCA ordination techniques, and this result matches with that of **Ahmed and Hussein (2004)**.

CONCLUSION

It was concluded that, the AGP in LM was rich with its natural flora (43 species): as a source for human food, medicinal purposes, animal fodder, ecological importance, among others. The natural plant wealth of the study area belongs to 38 genera and is related to 22 families. The perennials are the most frequent species (62.7%), followed by the annual species (37.2%). The abundance of aquatic plants or hydrophytes such as *Lemna gibba*, *Typha domingensis*, *Eichhornea crassipes*, and *Phragmites australis* in

AGP may be attributed to the high eutrophication because of the drainage water from the drains and canals, as well as adjacent cultivated lands, which led to the dominance of the aquatic flora.

Chenopodiaceae has the highest contribution to the total number of the recorded species (comprising 8 species-18.6%), followed by Asteraceae and Poaceae, with 5 species for each (11.6%) of the total number of the recorded species. Therophytes (Th) have the highest contribution among all life forms recorded in this study area, represented by 16 species (37%) of the total species. The floristic analysis indicates that the Mediterranean (mono-, bi- and pluriregional) chorotype constitutes the largest group (18 species or about 41.86 of the total flora) with variations in their life forms. This is because AGP is located on the northern Mediterranean Sea coast, where the Mediterranean class increased northward. There is no one variable that acts alone, while all environmental variables affect the growth and distribution of vegetation.

TWINSPAN and DCA classification have divided the vegetation that grows naturally in the 50 stands of AGP into four vegetation groups. In addition, CCA indicated that the most significant soil variables controlling the distribution and abundance of the plant communities in AGP are pH, EC, TDS, NO_3^-, P^{3+}, Na^+, Cl^-, TOC, TOM, Zn^{2+}, sand and silt. The study area supports only one type of habitat (wetlands), which can be distinguished into two main sub-systems. Those main sub-systems are marine wetlands and fresh wetlands. Moreover, many significant efforts and cooperation between various authorities are required for socio-economic development, environmental protection, and the reduction of the environmental risk of LM as one of the coastal lakes to achieve the sustainability of these wetlands. This can be achieved through the treatment of industrial, agricultural, and sewage waste before throwing it into the LM. Generally, assessing the lake's pollutants regularly is highly important.

ACKNOWLEDGMENT

I would like to express my gratitude to the soul of Prof. Hosny Abdel-Aziz Mosallam for his keen supervision, kind facilities during field trips, involvement in the practical aspect, and generous assistance, encouragement and kind support.

REFERENCES

Abdel Ghaffer, E. (2006). Impact of climate change on the hydrology of Lake El Manzala. First International Conference: Environmental Change in Lakes, Lagoons, and Wetlands of the Southern Mediterranean Region, 47pp.

Abdelhamid, A.; El-Barbary, M. and Mabrouk, E. D. (2013). Bacteriological status of Ashtum El-Gamil protected area. Egyptian Journal of Aquatic Biology and Fisheries., 17(3): 11–23. https://doi.org/10.21608/ejabf.2013.2173.

Ahmed, A. M. and Hussein, M. M. (2004). Residual levels of some heavy metals in the fish flesh and water from El-Manzala Lake, Egypt. J. King Saud Univ., 16(2): 187–196.

Ahmed, D. A. (2003). Current situation of the flora and vegetation of the Nile Delta region. MSc thesis in Botany. University of Tanta, Egypt.

Ayache, F.; Thompson, J. R.; Flower, R. J.; Boujarra, A., Rouatbi, F. and Makina, H. (2009). Environmental characteristics, landscape history, and pressures on three coastal lagoons in the southern Mediterranean region: Merja Zerg Morocco, Ghar el Melh Tunisia, and Lake Manzala Egypt. Hydrobiologia., 622(1): 15–43. https://doi.org/10.1007/s10750-008-9676-6.

Baker, H. G. (1991). The continuing evolution of weeds. Economic Botany., 45(4): 445–449. https://doi.org/10.1007/BF02930705.

Barko, J. W.; Smart, R.M. and McFarland, D. G. (1991). Interactive effects of environmental conditions on the growth of submersed aquatic macrophytes. Journal of Freshwater Ecology., 6(2): 199–207. https://doi.org/10.1080/02705060.1991.9665294.

Baxter, J. (2014). Vegetation Sampling Using the Quadrat Method. Department of Biological Sciences, 1–3. https://www.csus.edu/indiv/b/baxterj/bio 221b/vegetation sampling quadrat.pdf

Bernhardt, C. E.; Stanley, J. D. and Horton, B. P. (2011). Wetland vegetation in Manzala lagoon, Nile delta coast, Egypt: Rapid responses of pollen to altered Nile hydrology and land use. Journal of Coastal Research., 27(4): 731-737. https://doi.org/10.2112/10A-00001.1.

Bhatta, K. P., Chaudhary, R. P., and Vetaas, O. R. (2012). A comparison of systematic versus stratified-random sampling design for Gradient analyses: A case study in subalpine Himalaya, Nepal. Phytocoenologia., 42(3–4): 191–202. https://doi.org/10.1127/0340-269X/2012/0042-0519

Bhowmik, S. (2022). Ecological and economic importance of wetlands and their vulnerability: a review. In:"Research Anthology on Ecosystem Conservation and Preserving Biodiversity.", 11–27. https://doi.org/10.4018/978-1-7998-1226-5.ch006.

Boulos, L. (1999). Flora of Egypt, vol. 1. Cairo: Al Hadara Publishing, 417.

Boulos, L. (2000). Flora of Egypt VII Al Hadara Publishing Cairo, Egypt. ISBN-13: 9789775429223.

Boulos, L. (2005). Flora of Egypt (Alismataceae-Orchidaceae). Vol. 4. Al Hadara Publishing, Cairo, Egypt.

Boulos, L. (2009). Flora of Egypt checklist revised annotated edition. Al-Hadara Publishing, Cairo, 198-201.

Bouyoucos, G. J. (1962). Hydrometer Method Improved for Making Particle Size Analyses of Soils 1. Agronomy Journal, 54(5): 464–465. https://doi.org/10.2134/agronj1962.00021962005400050028x.

Braak, C. J. (1988). CANOCO—an extension of DECORANA to analyze species-environment relationships. Vegetation, 75(3): 159-160.

Braun-Blanquet, J. (1933). Phytosociological nomenclature. Ecology, 14(3): 315–317.

Carignan, R. and Kalff, J. (1980). Phosphorus sources for aquatic weeds: Water or sediments. Science., 207(4434): 987–989. https://doi.org/10.1126/science.207.4434.987.

Carter, M.R. and Gregorich, E.G. (2009). Soil Sampling and Methods of Analysis. In Journal of Environmental Quality., 38(1): 375. https://doi.org/10.2134/jeq2008.0018br.

Cronk, B. C. (2020). How to use PASW® statistics: A step-by-step guide to analysis and interpretation. Routledge, Sixth ed. London and New York.

Cummins, K. W. (1962). An Evaluation of Some Techniques for the Collection and Analysis of Benthic Samples with Special Emphasis on Lotic Waters. American Midland Naturalist., 67(2): 477-504. https://doi.org/10.2307/2422722.

Curtis, J. and McIntosh, R. (1950). The Interrelations of Certain Analytic and Synthetic Phytosociological Characters Author (s): J . T . Curtis and R . P . McIntosh Published by : Ecological Society of America Stable, Ecology., 31(3): 434-455. http://www.jstor.org/stable/1931497.

Dale, H. M. and Miller, G. E. (1978). Changes in the aquatic macrophyte flora of Whitewater Lake near Sudbury, Ontario from 1947 to 1977. Canadian Field-Naturalist., 92(3): 264-270.

Daryadel, E. and Talaei, F. (2014). Analytical Study on Threats to Wetland Ecosystems and their Solutions in the Framework of the Ramsar Convention. International Journal of Social, Behavioral, Education, Economic, Business and Industrial Engineering., 8(7): 2100-2110.

Dowidar, N. M. and Abdel-Moati, A. R. (1983). Distribution of nutrient salts in Lake Manzalah (Egypt). Rapp PV Comm. Int. Mer Médi.t., 28, 185-188.

Du Laing, G.; Van Ryckegem, G.; Tack, F. M. and Verloo, M. G. (2006). Metal accumulation in intertidal litter through decomposing leaf blades, sheaths, and stems of *Phragmites australis*. Chemosphere., 63(11): 1815-1823. https://doi.org/10.1016/j.chemosphere.2005.10.034

EEAA (Egyptian Environmental Affairs Agency). **(1997)**. First National Report to the Convention on Biological Diversity. National Biodiversity Unit, Ministry of State for Environmental Affairs press, Egypt. 82pp.

EEAA. (2003). Efforts are made by the State Ministry for Environmental Affairs to improve the environmental conditions of El Manzala Lake. EEAA, Cairo, Egypt.

EEAA. (2012). Natural Protected Areas in Egypt. Report prepared by the nature conservation sector, Ministry of State for Environmental Affairs press, Egypt.

El-Ameir, Y. A. and Shawky, R. A. (2017). Floristic Features and Vegetation Structure of Salt Affected Lands at the North Nile Delta, Egypt., 46(1): 71–88.

El-Gamal, A. A. (2017). Egyptian Nile Delta coastal lagoons: alteration and subsequent restoration. In:"Coastal Wetlands: Alteration and Remediation."Finkl, C. W. & Makowski, C. (Eds.). Springer., 21: 411-434. doi: 10.1007/978-3-319-56179-0_13.

Elnaggar, A. and El-Alfy, M. (2016). Physiochemical Properties of Water and Sediments in Manzala Lake, Egypt. Journal of Environmental Sciences, 45(2): 157–174.

El-Serehy, H. A.; Aboulela, H.; Al-Misned, F.; Kaiser, M.; Al-Rasheid, Kh. and Ezz El-Din, H. (2012). Heavy metals contamination of a Mediterranean Coastal Ecosystem, Eastern Nile Delta, Egypt. Turkish Journal of Fish. and Aquatic Sciences., 12(4): 751-760.doi: 10.4194/1303-2712-v12_4_03.

Fishar, M. R. A. (1999). Distribution and abundance of benthic assemblages in the El-Gamil basin (Lake Manzalah, Egypt). B. macrobenthos. Bulletin of the National Institute of Oceanography and Fisheries (Egypt)., 25: 167–180.

GAFRD. (2014). General authority for fish resources development. In Fish statistics yearbook. Ministry of Agriculture and Land Reclamation Cairo, Egypt.

Geene, R.; Meininger, P. L. and van Westrienen, R. (1989). Passage of Eurasian waders through northern Egypt, spring 1990. "Ornithological Studies in Egyptian Wetlands.", Meininger, P., & Atta, G. A. Foundation for Ornithological Research in Egypt., 90: 1–94.

Gore, K.; Foundation, T. C.; Parasnis, A.; Energy, T.; Kazi, S. and Energy, T. (2016). World Wetlands Day, 2008. September., p.1. https://doi.org/10.13140/RG.2.2.12589.49125.

Hamza, A. and Amer, A. (2022). Fish production from the Northern Lakes. Current Situation and Future Development. Alexandria Science Exchange Journal., 43(3): 765-772. doi: 10.21608/asejaiqjsae.2022.241920.

Hao, X.; Ball, B. C.; Culley, J. L. B.; Carter, M. R. and Parkin, G. W. (2008). Soil density and porosity. In: "Soil sampling and methods of analysis". Second ed. Boca Raton, pp. 179-196. https://doi.org/10.1201/9781420005271.ch57.

Harhash, K. A.; El-Henawy, M. T.; Fattah, H. F. A. and Antar, M. S. (2015). Conservation-oriented habitat classification scheming and mapping of Egypt. Environmental Systems Research., 4(1): 1–7. https://doi.org/10.1186/s40068-015-0034-1.

Hegazy, A. K. and Amer, W. M. (2002). Altitudinal and latitudinal diversity of the flora on the eastern and western sides of the Red Sea. In Biodiversity. Springer., pp. 197–216.

Hill, M. O. and Gauch, H. G. (1980). Detrended correspondence analysis: an improved ordination technique. In:"Classification and ordination: Symposium on advances in vegetation science, Nijmegen." van der Maarel, E. (Ed.). Springer Netherlands, May 1979, pp. 47-58. The Netherlands.

Hill. (1997). TWINSPAN – A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Ecology and Systematics, Cornell University, Ithaca, NY, US.

Horvath, E. K.; Christensen, J. R.; Mehaffey, M. H. and Neale, A. C. (2017). Building a potential wetland restoration indicator for the contiguous United States. Ecological Indicators., 83: 463–473. https://doi.org/10.1016/j.ecolind.2017.07.026.

HTC (Higher Technical Committee). **(2018)**. Report of the review of the borders of the Ashtum El-Gamil protected area - Port Said. It was issued by the decision of the Minister of Environment, 1633, p.9. Translated from the Arabic edition.

Https://www.eeaa.gov.eg/portals/0/eeaaReports/N-protect/ashtom.pdf (n.d).(In Arabic).

Ibrahim, E. A. (1989). Studies on phytoplankton in some polluted areas of Lake Manzalah. Bulletin of the National Institute of Oceanography and Fisheries(Egypt). Cairo., 15(1): 1–19.

Ibrahim, M. (1993). Protected Area in Egypt. NCS, EEAA.

Ismail, A. and Hettiarachchi, H. (2017). Environmental Damage Caused by Wastewater Discharge into the Lake Manzala in Egypt., 5(6): 141–150. https://doi.org/10.11648/j.bio.20170506.14.

Jackson, M. L. (2005). Soil chemical analysis: advanced course. UW-Madison Libraries Parallel Press.

Johnston, R. B. (2016). Arsenic and the 2030 Agenda for sustainable development. In: Arsenic Research and Global Sustainability."Bhattacharya, P.;Vahter, M.; Jarsjö, J.; Kumpiene, J., Ahmad, A.; Sparrenbom, C.; Jacks, G.; Donselaar, M.E.; Bundschuh, J. & Naidu, R. (Eds.). Proceedings of the 6th International Congress on Arsenic in the Environment, AS 2016., Stockholm, Sweden (1st ed.). CRC Press. pp. 12–14. https://doi.org/10.1201/b20466-7.

Kadereit, G., Ackerly, D., and Pirie, M. D. (2012). A broader model for C4 photosynthesis evolution in plants is inferred from the goosefoot family (Chenopodiaceae ss). Proceedings of the Royal Society B: Biological Sciences, 279(1741): 3304–3311. doi:10.1098/RSPB.2012.0440.

Kadono, Y. (1982). Occurrence of aquatic macrophytes in relation to pH, alkalinity, Ca^{++} >, Cl^{-}, and conductivity. Japanese Journal of Ecology., 32(1): 39-44. https://doi.org/10.18960/seitai.32.1.

Kaiser, M. F.; Aboulela, H. A.; El-Serehy, H. A. and Ezz El-Din, H. (2012). Heavy metals contamination of a Mediterranean coastal ecosystem, eastern Nile delta, Egypt. In: "International perspectives on global environmental change." Stephen, S.Y. & Steven, E. S.pp. 297-310.

Khedr, A. A. and Zahran, M. A. (1999). Comparative study on the plant life of two Mediterranean Deltaic lakes in Egypt. Ass Univ Bull Environ Res., 2(1): 1-14.

Kottek, M., Grieser, J., Beck, C., Rudolf, B., and Rubel, F. (2006). World map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift., 15(3): 259–263. https://doi.org/10.1127/0941-2948/2006/0130.

Li, W.; Cui, L.; Sun, B.; Zhao, X.; Gao, C.; Zhang, Y. and Ma, W. (2017). Distribution patterns of plant communities and their associations with environmental soil factors on the eastern shore of Lake Taihu, China. Ecosystem Health and Sustainability., 3(9): 1385004. https://doi.org/10.1080/20964129.2017.1385004.

Lionello, P. (2012). The Climate of the Mediterranean Region: From the Past to the Future. In: "The Climate of the Mediterranean Region." Elsevier Inc., (1st ed.).

Mansour, H.; AH El-kady, M.; H Abu Almaaty, A. and M Ramadan, A. (2018). Effect of environmental pollution on gonads histology of the Nile Tilapia, Oreochromis niloticus from Lake Manzala, Egypt. Egyptian Journal of Aquatic Biology and Fisheries, 22(5): 563–572.

Mashaly, I. A.; Ayyad, S. M. and El-Ameir, Y. A. (2013). Floristic features of the plant Life of the river Nile in Egypt. Journal of Environmental Sciences., 3(3): 155–169. https://www.researchgate.net/publication/237052264.

Mashaly, I. A.; El-Habashy, I. E.; El-Halawany, E. F. and Omar, G. (2008). Habitats and plant communities in the Nile Delta of Egypt I. Deltaic Mediterranean coastal habitat. Pakistan Journal of Biological Sciences: PJBS., 11(22): 2532–2544.doi. 10.3923/pjbs.2008.2532.2544.

Maswada, H. F. and Elzaawely, A. A. (2013). Ecological investigation of three geophytes in the Deltaic Mediterranean coast of Egypt. Pakistan Journal of Biological Science., 16(23): 1662-1674. doi.10.3923/pjbs.2013.1662.1674.

Matthews, G. V. T. (1993). Ramsar Convention.In: "The Ramsar Convention on Wetlands: its history and development.", The Ramsar Convention Bureau, Gland, Switzerland, pp. 4-7.

McCune, B. and Mefford, M. J. (2006). PC-ORD version 5.10: Multivariate Analysis of Ecological Data. MjM Software. Gleneden Beach, OR, USA.

Meininger, P. and Atta, G. A. M. (1994). Ornithological studies in Egyptian wetlands 1989/90. Foundation for Ornithological Research in Egypt.

Meininger, P. L., and Atta, G. A. (1990). Ornithological studies in Egyptian wetlands. Preliminary Report. The Eastern Mediterranean Wader Project.

Mitra, S., Wassmann, R., and Vlek, P. L. G. (2003). Global inventory of wetlands and their role in the carbon cycle. ZEF Discussion Paper on Development Policy, Bonn, 64, 57. https://doi.org/10.22004/ag.econ.18771.

Mitsch, W. J. and Gosselink, J. G. (2015). Wetlands. John Wiley & Sons.

Negm, A. M.; Bek, M. A. and Abdel-Fattah, S. (Eds.). (2018). Climate Change and Biodiversity.In: Egyptian Coastal Lakes and Wetlands: Part II. Springer., 72, p.261. https://doi.org/10.1007/978-3-319-93611-6.

Pipan, T. and Culver, D. C. (2019). Wetlands in cave and karst regions. In Encyclopedia of caves (3rd ed.). Elsevier Inc., pp. 1156-1164. https://doi.org/10.1016/b978-0-12-814124-3.00135-7.

Räike, A.; Pietiläinen, O. P.; Rekolainen, S.; Kauppila, P.; Pitkänen, H.; Niemi, J.; Raateland, A., and Vuorenmaa, J. (2003). Trends of phosphorus, nitrogen, and chlorophyll concentrations in Finnish rivers and lakes in 1975-2000. Science of the Total Environment, 310(1–3), 47–59. https://doi.org/10.1016/S0048-9697(02)00622-8

Rahman, I. U.; Hart, R. E.; Ijaz, F., Afzal, A.; Iqbal, Z.;Calixto, E. S.; Fathi, E., Allah, A.; Alqarawi, A. A.; Hashem, A.; Al-arjani, A. F.; Kausar, R. and Haq, S. M. (2022). Environmental variables drive plant species composition and distribution in the moist temperate forests of Northwestern Himalaya, Pakistan. Plos one., 17(2): 2, e0260687. https://doi.org/10.1371/journal.pone.0260687.

Ramadan, A. A. (2002). Population dynamics and multivariate analysis of vegetation in Lake Manzala, Egypt.

Rashad, H. M. and Abdel-Azeem, A. M. (2010). Lake Manzala, Egypt: A bibliography. Assiut Univ. J. of Botany., 39(1): 253–289.

Raunkiaer, C. (1934). The life forms of plants and statistical plant geography; are the collected papers of C. Raunkiaer. The Life Forms of Plants and Statistical Plant Geography; Being the Collected Papers of C. Raunkiaer.

Reeve, R. C.; Bower, C. A.; Brooks, R. H. and Gschwend, F. B. (1954). A Comparison of the Effects of Exchangeable Sodium and Potassium upon the Physical Condition of Soils. Soil Science Society of America Journal., 18(2): 130–132. https://doi.org/10.2136/sssaj1954.03615995001800020004x.

Rezania, S.; Kamyab, H.; Rupani, P. F.; Park, J., Nawrot, N.; Wojciechowska, E.; Yadav, K. K.; Lotfi Ghahroud, M.; Mohammadi, A. A.; Thirugnana, S. T.; Chelliapan, S.; and Cabral-Pinto, M. M. S. (2021). Recent advances in the removal of phosphorus in aquatic plant-based systems. Environmental Technology and Innovation., 24, 101933. https://doi.org/10.1016/j.eti.2021.101933.

Rhoades, J. D. (2018). Salinity: Electrical conductivity and total dissolved solids. In: "Methods of Soil Analysis, Part 3: Chemical Methods.", American Society of Agronomy, Inc., 5: 417–435. https://doi.org/10.2136/sssabookser5.3.c14.

Richards, L. A.; Allison L; Bernstein C A; Bower J W; Brown M; Fireman J T; Hatcher H E; Hayward G A Pearson R C; Reeve, L. E. and Richards Wilcox, A. L. (1954). Diagnosis and Improvement of. Soil Science Society of America Journal, 18, 348.

Sallam, G. A. H. and Elsayed, E. A. (2018). Estimating relations between temperature, relative humidity as independent variables and selected water quality parameters in Lake Manzala, Egypt. Ain Shams Engineering Journal., 9(1): 1–14. https://doi.org/10.1016/j.asej.2015.10.002.

Sector, N. C. (2006). Protected areas of Egypt: Towards the future. Egyptian Environmental Affairs Agency, Cairo, 71.

Shaltout, K. and Galal, T. (2007). The ecosystem of Lake Manzala. Integrated coastal zone management project of the port said area. Faculty of Agriculture, University of El-Zagazig, El-Zagazig, Egypt. https://doi.org/10.13140/RG.2.1.2044.1448.

Shaltout, K. H. and Galal, T. M. (2006). Comparative study on the plant diversity of the Egyptian northern lakes. Egypt J Aquat Res., 32(2): 254–270.

Shaltout, K. H.; Sharaf El-Din, A. and Ahmed, D. A. (2010). Plant life in the Nile Delta. Tanta: Tanta University Press. p.158.

Shaltout, K.; Ali, M.; Hassan, L. and Galal, T. (2005). Habitat and vegetation of Lake Edku, Egypt. Taeckholmia., 25(1): 61–90.

Shaltout, K.; El-bana, M. and Galal, T. (2017). Coastal Lakes as Hot Spots for Plant Diversity in Egypt.In: "Egyptian Coastal Lakes and Wetlands: Part II." Springer., pp. 129–146. https://doi.org/10.1007/698.

Soltanpour, P. N. (1991). Determination of Nutrient Availability and Elemental Toxicity by AB-DTPA Soil Test and ICPS. 16: 165–190. https://doi.org/10.1007/978-1-4612-3144-8_3.

Swacha, G., Botta-Dukát, Z., Kącki, Z., Pruchniewicz, D., and Załnierz, L. (2017). Performance comparison of sampling methods in the assessment of species composition patterns and environment-vegetation relationships in species-rich grasslands. Acta Societatis Botanicorum Poloniae., 86(4), 1–15. https://doi.org/10.5586/asbp.3561

Tackholm, V. and Boulos, L. (1974). Students' flora of Egypt.

Takhtajan, A. (1986). Floristic regions of the world. The University of California Press.

Ter Braak, C. J. F. and Smilauer, P. (2002). CANOCO reference manual and CanoDraw for Windows user's guide: software for canonical community ordination (version 4.5). www. CANOCO. com.

UNESCO (United Nations Educational, Scientific, and Cultural Organization). (1979). Map of the World Distribution of Arid Regions. Explanatory Note, UNESCO, Paris. p. 54. Map scale 1/ 25,000,000. https://doi.org/10.1163/9789004481206_130.

USDA. **(2017**). Sodium Adsorption Ratio (SAR). 13–14.

Vermaat, J. E. and De Bruyne, R. J. (1993). Factors limiting the distribution of submerged water plants in the lowland River Vecht (The Netherlands). Freshwater Biology., 30(1): 147–157. https://doi.org/10.1111/j.1365-2427.1993.tb00795.x.

Wael A. Omar et al. (2017). Assessment of ecosystem condition using some biotic and abiotic components along Ashtoum El-Gamil Protected Area, Lake Manzala, Egypt Wael., pp. 1–21. https://doi.org/10.12816/0043178.

Zahran, M. A. (1992). Egypt: The Gift of the Nile. In The vegetation of Egypt, Springer., pp. 1–3.

Zahran, M. A. (2010). Climate-Vegetation: Afro-Asian Mediterranean and Red Sea Coastal Lands.,4. Springer Science & Business Media. doi.10.1007/978-90-481-8595-5_1.

Zahran, M. A. and Willis, A. J. (2009). The Nile Region. In The vegetation of Egypt., Springer., pp. 251–303.

Zahran, M. A., and Willis, A. J. (2008). The vegetation of Egypt. Springer Science & Business Media., 2.

Zahran, M. A.; Ziada, M. E. A.; El-Demerdash, M. A. and Khedr, A. A. (1989). A note on the vegetation on islands in Lake Manzala, Egypt. Vegetation., 85(1–2): 83–88. https://doi.org/10.1007/BF00042258.

Zalat, A. A., and Saleh, R. (2018). Environmental assessment of Lake Manzala was inferred from diatom analysis of the lake surface sediments. Delta Journal of Science., 39(2): 39–51. https://doi.org/10.21608/djs.2018.138906.

Zohary, M. (1973). Geobotanical foundations of the Middle East. Fischer.

ARABIC SUMMARY

التقييم البيئي للنباتات في الأراضي الرطبة: دراسة حالة لمحمية أشتوم الجميل، بحيرة المنزلة، مصر

منى مصطفى[1,*]، حسني عبد العزيز مسلم[1]، أشرف محمد يوسف[1]، البيلي السيد حطب[2]، أحمد هاشم محمد[1]
[1] قسم النبات، كلية العلوم، جامعة عين شمس، القاهرة، مصر
[2] قطاع حماية الطبيعة، وزارة البيئة، مصر
monamostafa@sci.asu.edu.eg

تطبيق الاستخدام الحكيم للأراضي الرطبة المصرية أثناء الإجراءات المحلية والوطنية، كمساهمة في تحقيق التنمية المستدامة في جميع أنحاء البلاد. محمية أشتوم هي جزء من بحيرة المنزلة وموطن مثالي للأراضي الرطبة. لسوء الحظ، تعرضت محمية أشتوم الجميل للعديد من التعديات التي أدت إلى فقدان التنوع البيولوجي وتدمير الموائل خلال العقود الماضية. لذلك هدفت هذه الدراسة إلى تقييم الحالة الراهنة لتوزيع الغطاء النباتي وعلاقته بالمتغيرات البيئية. تم تجميع العينات النباتية وعينات التربة من 50 موقع. من الناحية النباتية الاجتماعية، أظهر تقييم الغطاء النباتي أن محمية أشتوم الجميل هي موطن لـ 43 نوعًا، تنتمي إلى 38 جنسًا و 22 عائلة. تمتلك العائلة الرمرامية (Chenopodiaceae) أعلى مساهمة من إجمالي النباتات (18.6٪) ، تليها العائلة المركبة (Asteraceae) والنجيلية (Poaceae) 5 أنواع لكل منهما (11.6٪). تعد النباتات الحولية (37٪) والنباتات الأرضية (34.87٪) أكثر أشكال الحياة وفرة.من وجهة نظر الجغرافية النباتية، شكلت انواع البحر الأبيض المتوسط (أحادي وثنائي ومتعدد المناطق) أعلى نسبة من الأنواع النباتية (41.86٪). كشف تحليل المؤشرات ثنائي الاتجاه (TWINSPAN) أن الغطاء النباتي مصنف إلى 4 مجموعات. أكد Detrended Correspondence Analysis (DCA) على فصل مجموعات هذا الغطاء النباتي، وأشار Canonical Correspondence Analysis (CCA) إلى أن أهم المتغيرات البيئية التي تؤثر على توزيع هذه المجموعات هي الأس الهيدروجيني، والتوصيل الكهربائي، والأملاح الذائبة الكلية، والكربون العضوي الكلي، ونترات المادة العضوية الكلية، والصوديوم، والكبريتات، والمغنيسيوم، والرصاص، والزنك، والفوسفور، والرمل، والطمي. في الختام، طورت الحكومة المصرية مشروعًا بدأ في عام 2017 وأثر على التنوع البيولوجي وتركيب الموائل.