

Floristic composition of some drains south Manzala Lake

Toka E. El-Eraky^{a*}, Samia A. Haroun^a; Muhammad A. El-Alfy^b

^aBotany Department, Faculty of Science, Mansoura University, Egypt

^bNational Institute of Oceanography and Fisheries, NIOF, Egypt

*Correspondence: toka.eleraky@hotmail.com

Received: 26/5/2021
Accepted: 4/7/2021

Abstract: The Nile River irrigates Egypt's cultivated lands almost indefinitely through a massive network of canals and drains. The current study aimed to describe the floristic composition of the three drains (El-Serw, Hadous and Bahr El-Baqer drains) south Manzala Lake in the Nile Delta region. In each station, all plant species were recorded in 5 plots (25 m² each) and the relative frequency (IV=100) was estimated. The total number of the recorded flowering plant species in the present study is 50 (36 perennials, one biennials and 13 annuals), belonging to 43 genera and related to 27 families. The main families are Poaceae, Chenopodiaceae, and Asteraceae, which together account for 18 species, or about 36% of the total species reported. Ecologically, these species can be divided into four classes.; three submerged, seven floating, thirteen emergent and 27 terrestrial species. It is also self-evident that the El-Serw drain is the most floristically diverse of all the ecological sites, followed by Bahr El-Baqer drain, and finally Hadous drain. The terrestrial plants are the most frequent species in the different studied three ecological drains. Cryptophytes dominate the life-form spectrum in three drains, with therophytes, chamaephytes, and hemicryptophytes filling in the gaps. The floristic analysis of the study area reveals that, 12 species (24 % of the total recorded species) are Mediterranean taxa as well as 32 species (about 64 % of the total recorded species) are worldwide species (Cosmopolitan, Palaeotropical, Pantropical and Neotropical)

keywords: Drains, Floristic analysis, Duration, Chorotype, Manzala Lake

1.Introduction

In Egypt, the main courses of River Nile provide an extremely important habitat and source of fresh water distributed by irrigation canals and revert into drainage canals. Most of these networks were established during the 19th century and amount approximately to a total length of 48 000 km [1]. The Nile River irrigates Egypt's cultivated lands almost indefinitely through a massive network of canals and drains. The total length of both water systems exceeds 47000 km >31000 km of canals and >16000 km of drains [2,3]. The majority of these drains and canals were dug during the last 150 years [4]. Egypt currently has a water shortage of 13.5 billion cubic metres per year (BCM/yr), which is expected to continue to expand. Currently, this water shortage is balanced by drainage reuse, which degrades the quality of the water [5].

These extensive channels support the riparian and aquatic vegetation but little is known about how these channels control and effect plant community structure, floristic composition, and species diversity [6]. According to Zahran & Willis [7], the vegetation along canal banks are classified into three types: aggressive species, bank retainers, and soil erosion controllers. Aggressive species are characterized by rapid and vigorous growth that inhibits the growth and establishment of many slow-growing and smaller plants. Many plant species growing along the banks of the Egyptian surface waters, involving the irrigation and drainage canals, are aggressive, including *Trifolium resupinatum*, *Cyperus laevigatus*, and *Phyla nodiflora*. These aggressive plants quickly and violently cover the bare soil. Furthermore, *Saccharum spontaneum*, *Cyperus alopecuroides*, *Arundo*

donax, and *Cyperus articulatus* form stands of tall spreading reeds.

The aquatic system comprises distinguished parts of the environment such as rivers, stream, lakes, estuaries, coastal and Deep Ocean waters [8]. Aquatic plants are plants that have adapted for living in aquatic environments such as (saltwater or freshwater). They are also referred to as hydrophytes to distinguish them from algae and other microphytes. A Hydrophyte is a plant that grows in or near water and is either emergent, submerged, or floating. Such plants do not face the problem of water shortage. They have developed mechanisms for the removal of extra water from their cells. Hydrophytes have broad leaves with a large number of stomata on their upper surfaces. This characteristic helps them to remove extra amount of water. In lakes, rivers and drains hydrophytes provide cover for fish, substrate for aquatic invertebrates, produce oxygen, and act as food source for some fish and wildlife [9]. Biogas processing, fuel, fertiliser, soil additives or mulch, mushroom culture, paints [10], and the reduction of water contaminants from paper-pulp mills, tanneries [11], and rubber and oil palm industries [12] are some of the other uses of hydrophytes.

The use of aquatic plants as natural filters for the subsidence of contaminants carried by water in rivers or lakes is thought to be a cost-effective and clean-up alternative for improving surface water quality. Indeed, aquatic plants have been widely used to clean polluted water almost anywhere in the world in recent decades [13]. Furthermore, aquatic plants play an important role in removing large amounts of nutrients [14], and metals [15,16,17] from the ecosystem by storing them in the roots and/or shoots, so hydrophytes have a high macronutrient remediation capacity due to their general quick growth and high biomass production.

From the ecological point of view, the study of the floristic structure and ecological studies of the aquatic ecosystems and particularly hydrophytes in the Nile Delta subregion, many researchers in the Nile Delta region have taken note of them for examples, Simpson [18],

2.2. Selection of Stands and Estimation of Species Abundance

Hassib [19], El-Fiky[20], Abu Ziada [21], Serag [22], Shaltout and El- Sheikh [23], Zaharn et al. [24], Serag and Khedr [25], Khedr and El-Demerdash [26], Khedr and Serag [27], Zahran et al. [28], El-Hennawy [29], Serag et al. [30], Serag [31], El-Amier and Al-Mamory [32], El-Amier and Abd El-Gawad [33], El-Amier et al. [34][35], etc. The current study's aim is to explain the floristic composition of the three drains south Manzala Lake in the Nile Delta region.

2. Materials and methods

2.1. Study area

The northern Egyptian coastal lagoons (Mariout, Idku, Burullus, Manzala and Bardawil Lake) are some of Egypt's most active natural systems, with abundant birdlife and fish production. Due to the industrial, agricultural, and sewage wastes pumped into the lakes through drains, there is a high degree of lake water contamination [36,37].

One of these coastal lakes is Manzala Lake, located at the northeastern part of Nile delta, Egypt. There are different drains in the southern part of the Lake. The studied three drains are distributed as Figure (1); El-Serw drain is located at the southwestern part of lake, Hadous drain is located among central part to the southeastern part of the lake and Bahr El-Baqar drain in the southeastern part of the lake

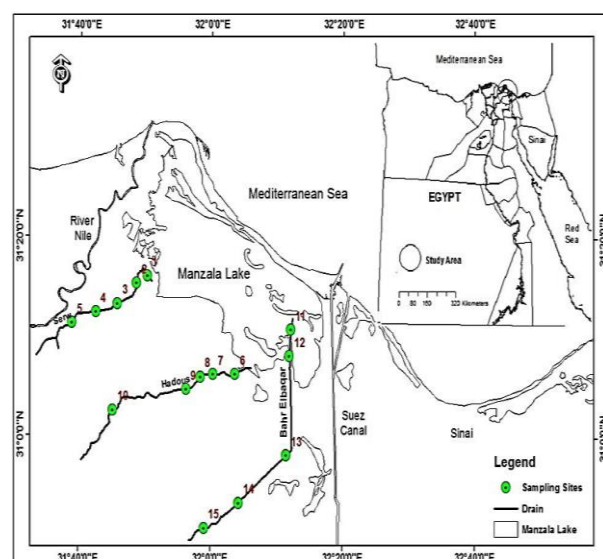


Figure 1: Location map showing studied drains, south Manzala Lake

The present study is represented by 15 stands along the drains of Manzala Lake (El-Serw, Hadous and Bah El-Baqer drains). The stands are distributed in the studied drains to represent their different habitats and to ensure sampling of wide range of vegetation variations. In each station, all plant species were recorded in 5 plots (25 m² each) and the relative frequency (IV=100) was estimated in one stand according to Westhoff and Van der Maarel [38] and Muller-Dombois and Ellenberg [39].

During each trip, plant specimens were collected from the various stands for identification. All samples were kept in the Herbarium of Botany Department, Faculty of Science at Mansoura University. The description and classification of their life-forms were according to Raunkiaer [40,41]. The identification, classification and floristic composition were according to Tutin *et al.* [42], Davis [43], Zohary [44], Täckholm [45], Meikle [46], Feinbrun-Dothan [47] updated by Boulos [48].

3. Results and DiscussionFloristic Features

Floristic composition and distribution of the plant life.

The recorded hydrophytes and canal bank species in the three studied drains of the study area are shown in Table 1. As mentioned before these drains are as follows: drain 1 (El-Serw), drain 2 (Hadous) and drain 3 (Bahr El-Baqer). All are located in South Manzala Lake, East Nile Delta. The total number of the recorded species is 50. Ecologically, these species can be divided into four classes, namely: a) three submerged hydrophytes, b) seven floating hydrophytes, c) thirteen emergent species and d) 27 terrestrial species (Figure 2).

a) The submerged hydrophytes include two species, namely: *Ceratophyllum demersum* and *Potamogeton pectinatus* recorded in three drains of the south Manzala Lake, (P = 60 and 33.33 %, respectively). *Myriophyllum spicatum* occurs in two drains (El-Serw and Hadous) of the study area (P =20%).

b) The seven floating hydrophytes are: *Azolla filiculoides*, *Eichhornia crassipes*, *Lemna gibba*, *Lemna minor*, *Ludwigia stolonifera*, *Nymphaea lotus* and *Pistia*

stratiotes. Out of these hydrophytes, three species have been recorded in three ecological drains with presence value (80, 33.33 and 33.33%, respectively). These species are: *Eichhornia crassipes*, *Ludwigia stolonifera* and *Pistia stratiotes*. Each of the other four floating hydrophytes has been recorded in two drains with presence value (20, 13.33, 33.33 and 26.67 %, respectively). These plants are *Azolla filiculoides*, *Lemna gibba*, *Lemna minor* and *Nymphaea lotus*.

c) The emergent species are 13 taxa. Out of these, eight species namely *Alternative sessilis*, *Cyperus alopecoroids*, *Cyperus articulatus*, *Echinochloa stagnina*, *Phragmites australis*, *Ranunculus sceleratus*, *Paspalidium geminatum* and *Typha domingensis* are very common. Each species has been recorded in all ecological drains with presence value (26.67, 66.67, 40, 93.33, 93.33, 46.67, 33.33 and 60 %, respectively). Two species namely, *Persicaria salicifolia* and *Saccharum spontaneum* have been recorded in two ecological drains (P = 20 and 26.67 %, respectively). Whereas, three other species have been recorded in only one drain (P = 6.67, 13.33 and 6.67 %, respectively), these are *Leerisa hexandra*, *Persicaria lapathifolia* and *Rorippa palustris*.

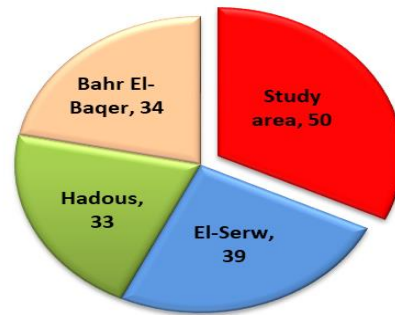
The terrestrial species represent the majority of the flora in the study area (27 species). These species occur either as weed flora associating the field crops or canal bank plants of the cultivated lands. Seven species have been recorded in three ecological drains (P = 33.33, 26.67, 33.33, 53.33, 46.67, 40 and 20 %, respectively). They are *Amaranthus lividus*, *Convolvulus arvensis*, *Pluchea dioscoridis*, *Cynodon dactylon*, *Malva parviflora*, *Rumex dentatus* and *Symphyotrichum squamatum*. Ten species have been recorded in two drains (P =13.33, 33.33, 26.67, 20, 20, 20, 26.67, 13.33,

13.33 and 33.33 %, respectively). These species are *Arundo donax*, *Chenopodium album*, *Chenopodium murale*, *Conyza bonariensis*, *Cynanchum acutum*, *Eclipta prostrata*, *Ipomoea carnea*, *Portulaca oleracea* and *Tamarix nilotica*. Ten species have been recorded in one drain only (P=13.33, 6.67, 6.67, 6.67, 6.67, 6.67, 13.33 and 20 %, respectively), these taxa are *Alhagi graecorum*, *Atriplex portulacoides*, *Atriplex*

prostrate

a) *Cyperus rotundus*, *Imparata cylindrical*, *Mentha longifolia*, *Pennisetum setaceum*, *Sesbania sesban*, *Solanum nigrum* and *Suaeda pruinose*.

This agrees more or less with the findings of El-Shiekh [49] on the canal drain vegetation in the middle Delta region, Shaltout *et al.* [50] on the vegetation of different habitats in the south Nile Delta, Shaltout *et al.* [51] studied the plant life in the Nile Delta and Al-Mamoori [52] on the plant life of the Damietta branch, River Nile and El-Amier and Al-Mamory [32] on relationship between aquatic plants and environmental factors along Rosetta Branch of the River Nile in Egypt.



Total number of recorded species in study area and three drains

Figure 2. Total number of recorded species in study area and three selected drains south Manzala Lake

Table 1. Floristic composition, life forms and plant diversity of three main drains (n=15) south Manzala Lake of Egypt

Species	Dura tion	Life form	Chorotype	Three drains of south Manzala Lake			P%
				El-Serw	Hadous	Bahr El-Baqer	
Aquatic plants							
1.Submerged hydrophytes							
<i>Ceratophyllum demersum</i> L.	Per.	Hy	COSM	+	+	+	60
<i>Myriophyllum spicatum</i> L.	Per.	Hy	COSM	+	+	-	20
<i>Potamogeton pectinatus</i> L.	Per.	Hy	ME, IR-TR	+	+	+	33.33
2.Floating Hydrophytes							
<i>Azolla filiculoides</i> Lam.	Ann	Hy	COSM		+	+	20
<i>Eichhornia crassipes</i> (C. Mart.) Solms	Per.	Hy	NEO	+	+	+	80
<i>Lemna gibba</i> L.	Per.	Hy	COSM	+	+	-	13.33
<i>L. minor</i> L.	Per.	Hy	COSM	-	+	+	33.33
<i>Ludwigia stolonifera</i> (Guill. & Perr.) P.	Per.	He	S - Z	+	+	+	33.33
<i>Nymphaea lotus</i> L.	Per.	Hy	PAL	+	+	-	26.67
<i>Pistia stratiotes</i> L.	Per.	Hy	PAN	+	+	+	33.33
3.Emergent species							
<i>Alternanthera sessilis</i> (L.) DC.	Per.	He	PAN	+	+	+	26.67
<i>Cyperus alopecoroids</i> L.	Per.	He	PAN	+	+	+	66.67
<i>C. articulatus</i> L.	Per.	G, He	PAN	+	+	+	40
<i>Echinochloa stagnina</i> (Retz.) P. Beauv	Per.	G, He	PAL	+	+	+	93.33
<i>Leersia hexandra</i> Sw.	Per.	He	PAN	+	-	-	6.67
<i>Persicaria lapathifolia</i> (L.) Gray	Per.	G	PAL	+	-	-	13.33
<i>P. salicifolia</i> (Willd) Assenov	Per.	G	PAL	+	+	-	20
<i>Phragmites australis</i> (Cav.) Trin. ex Steud	Per.	G, He	COSM	+	+	+	93.33
<i>Ranunculus sceleratus</i> L.	Ann.	Th	ME, IR-TR, ER-SR	+	+	+	46.67
<i>Rorippa palustris</i> (L.) Besser.	Bi.	Th	ER-SR, IR-TR, ME	+	-	-	6.67
<i>Paspalidium geminatum</i> (Forssk.) Stapf	Per.	He	PAL	+	+	+	33.33
<i>Saccharum spontaneum</i> L. Mant. Alt	Per.	G, He	ME, PAL	+	+	-	26.67
<i>Typha dominqensis</i> (Pers.) Poir.	Per.	He	PAN	+	+	+	60

ex Steud.							
Terrestrial							
Alhagi graecorum Boiss.	Per.	H	PAL	-	-	+	13.33
Amaranthus lividus L.	An.	Th	ME, IR-TR	+	+	+	33.33
Arundo donax L.	Per.	G, He	CULT&NA T	+	+	-	13.33
Atriplex portulacoides L.	Per.	Ch	ME, IR-TR, ER-SR	-	-	+	6.67
A. prostrata Boucher ex DC.	Ann.	Th	ME, ER- SR, IR-TR	-	-	+	6.67
Chenopodium album L.	Ann.	Th	COSM	+	-	+	33.33
C. murale L.	Ann.	Th	COSM	-	+	+	26.67
Convolvulus arvensis L.	Per.	H	COSM	+	+	+	26.67
Conyza bonariensis L.	Ann.	Th	NEO	+	-	+	20
Pluchea dioscoridis (L.) DC.	Per.	Nph	S-Z, SA-SI	+	+	+	33.33
Cynanchum acutum L.	Per.	H	ME, IR-TR	+	-	+	20
Cynodon dactylon (L.) Pers.	Per.	G	COSM	+	+	+	53.33
Cyperus rotundus L	Per.	G	PAN	-	-	+	6.67
Eclipta prostrata (L.) L.	Ann.	Th	NEO	+	-	+	20
Imperata cylindrica (L.) Raeusch.	Per.	H	PAL	-	-	+	6.67
Ipomoea carnea Jacq.	Per.	Ch	Cult. & Nat.	+	-	+	26.67
Malva parviflora L.	Ann.	Th	ME, IR-TR	+	+	+	46.67
Mentha longifolia (L.) Muds.	Per.	He	PAL	+	-	-	6.67
Pennisetum setaceum (Forssk.) chiov.	Per.	H	ME, PAL	-	+	-	6.67
Plantago major L.	Per.	H	COSM	+	+	-	13.33
Portulaca oleracea L.	Ann.	Th	IR-TR, SA- SI	+	+	-	13.33
Rumex dentatus L.	Ann.	Th	ME, IR-TR, ER-SR	+	+	+	40
Sesbania sesban (L.) Merr.	Ann.	Th	PAL	+	-	-	6.67
Solanum nigrum L.	Ann.	Th	COSM	+	-	-	13.33
Suaeda pruinosa Lange (Revise identification????)	Per.	Ch	ME	-	-	+	20
Symphytichum squamatum (Spren.) Nesom	Per.	Ch	NEO	+	+	+	20
Tamarix nilotica (Ehrenb). Bunge	Per.	Nph	S-Z, SA-SI	-	+	+	33.33
Number of stands	15			5	5	5	
Number of plots	75			25	25	25	
Number of perennials	36			28	26	25	
Number of biennials	1			1	-	-	
Number of annuals	13			10	7	9	
Total number of recorded species	50			39	33	34	
Species diversity							
Simposn index				0.78	0.74	0.69	
Shannon-evenness				0.69	0.65	0.61	
	Legend to life-form:		Legend to chorotype:				
Per: Perennials	Nph: Nanophanerophytes		COSM: Cosmopolitan		SA-SI: Saharo-Sindian		
Bi: Biennials	Ch: Chamaephytes		PAN: Pantropical		IR-TR: Irano-Turanian		
Ann: Annuals	H: Hemicryptophytes		PAL: Palaeotropical		Cult. & Nat.: Cultivated and Naturalized		
	G: Geophytes		NEO: Neotropical		S-Z: Sudano-Zambezian		
	H: Helophytes		ME: Mediterranean				
	Hy: Hydrophytes		ER-SR: Euro-Siberian				
	Th: Therophytes						

1.1. Life-Span in studied drains

In Egypt, most weeds are mostly herbaceous

either with woody base or with tuberous underground parts and few are shrubs [53,54]. As shown in Figure (3), the recorded species (50) growing in the research field can be classified into three main classes: perennials (36), biennials (1) and annuals (13 species). El-Serw drain is floristically considered the richest habitat type among all ecological drains in the study area, as it comprises 39 species. These species are represented by perennial species (28), biennials (1) and annual species (10). The flora of Hadous drain comprises 33 species which can be divided into 26 perennials and 7 annuals. In Bahr El-Baqer drain, 34 species are recorded (25 perennials and 9 annuals).

The above mentioned results reveal that, the majority of the species recorded in this study are primarily represented by perennials followed by annuals and partly by biennials. It is also self-evident that the El-Serw drain is the most floristically diverse of all the ecological sites, followed by Bahr El-Baqer drain, and finally Hadous drain. It is also clear that, the terrestrial plants are the most frequent species in the different studied three ecological drains, followed by the emergent species, then the floating hydrophytes and finally the submerged hydrophytes.

1.2 Life-Forms in studied drains

The structure of life forms provides information that can be used to assess how vegetation responds to changes in certain environmental factors [55]. The life-form spectra are significant physiognomic characteristics that chorologists and ecologists have used extensively in vegetation and floristic studies [56]. Raunkiaer [40,41] assigned the Mediterranean climate type as therophyte climate because of the high percentage (more than 50% of the total species) of this life-form in the Mediterranean floras. This is assured later by Hassib [19] in Egypt, Zohary [57] in Palestine and Quezel [58] in North Africa. The species recorded in this study are classified into five groups of life-forms as follows: cryptophytes, therophytes, chamaephytes, hemicryptophytes and nanophanerophytes. The major bulk of plants are mainly cryptophytes, which include helophytes, geophytes and hydrophytes (60%) and partly nanophanerophytes (4%).

Therophytes attain value of about 26%, chamaephytes value of 8% and hemicryptophytes value of 12% of the total recorded species (Figure 4). The percentages of the life-form spectra clearly differ from one ecological drain to the other. (Figure 4). In El-Serw drain, the recorded species (39) can be divided into the following life-forms: cryptophytes (69.23%), therophytes (28.20%), chamaephytes (5.12%), hemicryptophytes (7.69%) and nanophanerophytes (2.56%).

In Hadous drain, the recorded species (33) can be classified into the following five types of life forms: cryptophytes (78.78%), therophytes (18.18%), chamaephytes (3.03%), hemicryptophytes (9.09%) and nanophanerophytes (6.06%). In Bahr El-Baqer drain, the recorded species (34) are grouped into: cryptophytes (55.88%), therophytes (26.47%), chamaephytes (11.76%), hemicryptophytes (11.76%) and nanophanerophytes (5.88%). It's worth noting that cryptophytes dominate the life-form spectrum in all of the study area's ecological drains, with therophytes, chamaephytes, and hemicryptophytes filling in the gaps. The group of nanophanerophytes is represented by the minimum values among all ecological sites of the study area.

In the earlier study by El-Sheikh [49] which clarified about 59.3 % of the therophytes are recorded in the ruderal vegetation in the Nile Delta, Maswada [59] recorded about 50.2% of this life-form in Mediterranean coastal region of Kafr El-Sheikh Province. Otherwise, therophytes were lower than those reported by El-Amier [60] illustrated 32.86% on vegetation of canal bank in Nile Delta and Al-Mamoori [52] illustrated about 34.29% on the plant life of the Damietta branch, River Nile.

The percentage of cryptophytes (including: geophytes and helophytes) collectively achieved in the present study (17.5% each) comparable to Hassib [19] who recorded 25.8% of this life-form in the Egyptian flora, 15.9% in the Mediterranean region and 16.2% in the Egyptian Nile Delta region. This life form contributed about 25.8%, 20.5%, 20.5%, 26.3% and 28.57% for the studies of El-Sheikh [61], Al-Sodany [62], El-

Halawany [63], Shaltout *et al.* [50] and Al-Mamoori [52], respectively. Chamaephytes, hemicryptophytes and nanophanerophytes in the present study agree more or less with the findings of Hassib [19] in the Egyptian flora, Al-Sodany [62], Shalaby [64], Awad [65], Maswada [59], El-Amier [60], Al-Mamoori [52] and El-Amier and Al-Mamory[32.]

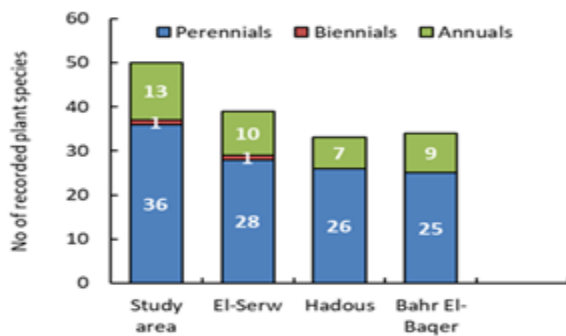


Figure 3. Plant life-span in the study area and three selected drains south Manzala Lake

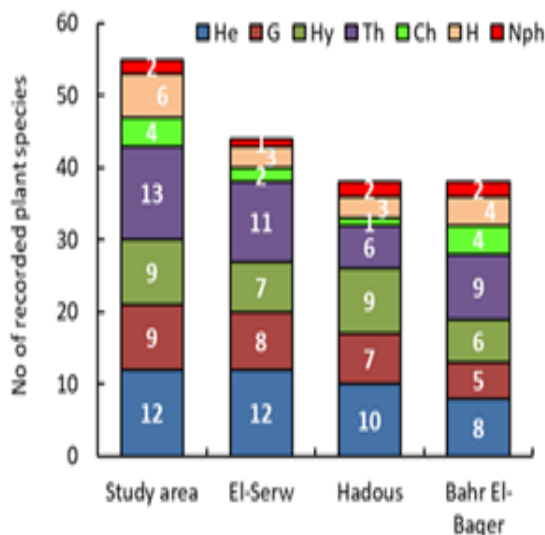


Figure 4. Plant life form in the study area and three selected drains south Manzala Lake

1.1. The Floristic analysis of the study area

The total number of the recorded flowering plant species in the present study is 50, belonging to 43 genera and related to 27 families (Figure 5). The main families are Poaceae (9 species), Chenopodiaceae (5 species), and Asteraceae (4 species), which together account for 18 species, or about 36% of the total number of species reported. Cyperaceae and Polygonaceae are represented by 3 species each. Each of the remaining families (22) has two or one species to represent it.

The floristic analysis of the study area as shown in Table (2) reveals that, 12 species or about 24 % of the total number of recorded species are Mediterranean taxa. These taxa are either pluriregional (5 species =10 %), biregional (6 species =12 %) or monoregional (one species = 2 %). It has been also found that, 32 species or about 64 % of the total number of the recorded species are worldwide species. These species are either Cosmopolitan (24 %), Palaetropical (18 %), Pantropical (14 %) and Neotropical (8 %). The other floristic groups are underrepresented, with only a few species representing each chorotype (Table 2). In general, the percentages of Cosmopolitan, Pantropical, Palaetropical, and Neotropical elements in all ecological sites studied are clearly comparable of the study area. The Mediterranean elements are highly represented in Bahr El-Baqer drain (9 taxa), followed by El-Serw drain (8 taxa) then Hadous drain (7 taxa). Similar studies have been described by Abd El-Ghani and Amer [66], El-Demerdash *et al.* [67], Shalaby [64], Khedr and El-Demerdash [26], El-Amier [68,60], El-Amier *et al.* [34].

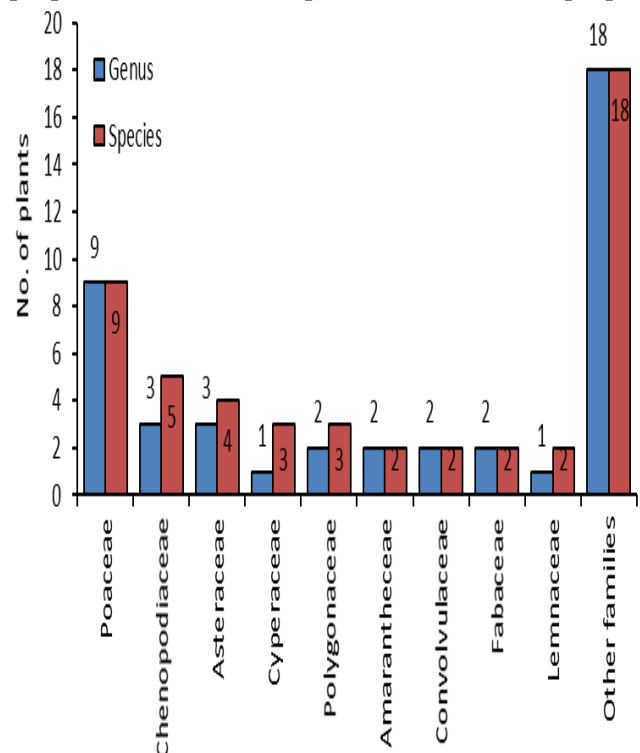


Figure 5. Total number of recorded plant genera and species in the families

Conclusion

It can be concluded that, aquatic plants have been widely used to filter polluted water almost

anywhere in the world in recent decades. The recorded flowering plant species is 50, belonging to a total of 43 genera and 27 families. These species can be divided into four ecological groups: three submerged, seven floating, 13 emergent, and 27 terrestrial species. Of all the ecological sites, El-Serw drain has the most diverse floristic diversity, followed by

Bahr El-Baquer drain, and finally Hadous drain. The floristic analysis of the study area reveals that, 12 species (24 % of the total recorded species) are Mediterranean taxa as well as 32 species (about 64 % of the total recorded species) are worldwide species (Cosmopolitan, Palaeotropical, Pantropical and Neotropical).

Table 2. Number of species and percentage of various floristic categories in three drains of the study area

Chorotype	Study area		Three drains of south Manzala Lake					
			El-Serw		Hadous		Bahr El-Baquer	
	No.	%	No.	%	No.	%	No.	%
World wide								
COSM	12	24	9	23.08	10	30.30	8	22.86
PAN	7	14	6	15.38	5	15.15	6	17.14
NEO	4	8	4	10.26	2	6.06	4	11.43
PAL	9	18	7	17.95	4	12.12	4	11.43
Pluri-regional elements								
ME+IR-TR+ER-SR	5	10	3	7.69	2	6.06	4	11.43
Bi-regional elements								
ME+IR-TR	4	8	4	10.26	3	9.09	4	11.43
ME+PAL	2	4	1	2.56	2	6.06	-	-
IR-TR+SA-SI	1	2	1	2.56	1	3.03	-	-
SA-SI+S-Z	2	4	1	2.56	2	6.06	2	5.71
Mono-regional elements								
ME	1	2	-	-	-	-	1	2.86
S-Z	1	2	1	2.56	1	3.03	1	2.86
Cult. & Nat.	2	4	2	5.13	1	3.03	1	2.86
Total	50	100	39	100	33	100	35	100

4. References

1. Khattab, A.F. (1992) The problem of water hyacinth in Egypt and methods for its control. – In: Proc. Second Natl. Symp. Water Hyacinth, Assiut Univ., Egypt, , p. 21-34. (in Arabic).
2. Khattab, A.F. and El-Gharably, Z.A. (1982) Aquatic weed control in irrigation canals by means of grass carp. *J. Egyptian Soc. Eng.,* 4: 14-26.
3. Khattab, A.F. and El-Gharably, Z.A. (1984) The problem of aquatic weeds in Egypt and methods of management. Proceedings of EWRS 3rd Symposium on Weed Problems in the Mediterranean., p: 335-344.
4. Hurst, H.E. (1952) The Nile. Constable, London..
5. Mohie El Din, M.O. and Moussa, A.M. (2016) Water management in Egypt for facing the future challenges. *Journal of Advanced Research.* 7(3): p. 403-412.
6. Nilsson, C., Grelsson, G., Johansson, M., & Sperens, U. ,(1989). Patterns of plant species richness along riverbanks. *Ecology* 70(1):p. 77-84.
7. Zahran, M.A. and Willis, A.J. (2003) Plant Life of the River Nile in Egypt. Mars Publishing, Reyadh, Saudi Arabia..
8. Duke, T.W. (1977). Pesticides in aquatic environments: An Overview. In: Quddus Khan, M. A. (ed). Pesticides in Aquatic Environments. Plenum Press, New York and London, pp. 81.
9. Lin, H.Y., Cooke, S.J., Wolter, C., Young, N. and Bennett, J.R. (2020) On the conservation value of historic canals for aquatic ecosystems. *Biological Conservation.,* 251: p.108764.
10. Vedanayagam, H. S., Lakshminarayan, G. and Thyagarayan, G. A (1983). preliminary report on the use of water hyacinth for making paints, in Proceedings of the International Conference on Water Hyacinth, Hyderabad, India,
11. Haider, S.Z., Malik, K.M., Rahman, M.N. and Ali, M.A. (1983). Pollution control by water hyacinth of waste effluents of

- pulp and paper mills and of tanneries. In Proceedings of the International Conference on Water Hyacinth, pp. 1–54, Hyderabad, India.
12. John, C.K. (1983) Use of water hyacinth in the treatment of effluent from rubber and oil palm industries. In Proceedings of the International Conference on Water Hyacinth, pp. 1–60, Hyderabad, India..
 13. Gopal, B. (2003), Perspectives on wetland science, application and policy. *Hydrobiologia*, 490: p. 1–10.
 14. Cronkand, J.K. and Fennessy, M.S. (2001). *Wetlands Plants. Biology and Ecology*, Lewis, Boca Raton, Fla, USA,
 15. Mays, P.A. and Edwards, G.S. (2001) Comparison of heavy metal accumulation in a natural wetland and constructed wetlands receiving acid mine drainage. *Ecological Engineering*,. **16(4)**: p. 487–500.
 16. Stoltz, E. and Greger, M. (2002). Accumulation properties of As, Cd, Cu, Pb and Zn by four wetland plant species growing on submerged mine tailings. *Environmental and Experimental Botany*, **47(3)**: p. 271–280.
 17. Baldantoni, D., Alfani, A., Di Tommasi, P., Bartoli, G., and De Santo, A.V. (2004) Assessment of macro and microelement accumulation capability of two aquatic plants. *Environmental Pollution*,. **130**, (2), pp. 149–156.
 18. Simpson, N.D. (1932). *A Report on the Weed Flora of the Irrigation Channels in Egypt*. Cairo: Government Press,
 19. Hassib, M. (1951). Distribution of plant communities in Egypt. *Bull. Fac. Sci., Fouad Univ.*, **29**: 259–261.
 20. El-Fiky, M.M. (1974). Studies on the ecology of water plants with special reference to *Eichhornia crassipes*. M.Sc. Thesis, Fac. Sci., Cairo Univ. Egypt.
 21. Abu Ziada, M.E. (1987) Studies on the macrohydrophytes in Egypt. I. *Phragmites australis* (Cav.) Trin. ex. Steud. ssp. *altissimus* (Benth). *Calyton. Mansoura Sci. Bull.*,. **14 (1)**: 169 – 187.
 22. Serag, M.S. (1991) Studies on the ecology and control of aquatic and canal bank weeds of the Nile Delta, Egypt. Ph. D. Thesis, Fac. Sci., Mansoura Univ., Egypt..
 23. Shaltout, K.H. and El-Sheikh, M.A. (1993) Vegetation environment relationships along water courses in the Nile Delta region. *Journal of Vegetation Science*,. **4**: 567 – 570.
 24. Zahran, M.A.; Soliman, M.I. and Serag, M.S. (1994) Analysis of habitats and anatomy of *Juncus subulatus* Forssk, Deltaic Mediterranean Coast, Egypt. *Arab Gulf J. Sci. Research*,. **12(2)**: 301–319.
 25. Serag, M.S. and Khedr, A.A. (1996) The shoreline and aquatic vegetation of El-Salam canal, Egypt. *Journal of Environmental Science*,. **11**: 141–163.
 26. Khedr, A.A. and El-Demerdash, M.A. (1997). Distribution of aquatic plants in relations to environmental factors in the Nile Delta. *Aquatic Botany*, **56**: 75 – 86.
 27. Khedr, A.A. and Serag, M.S. (1998). Environmental influences on the distribution and abundance of water lettuce (*Pistia stratiotes* L.) in Egypt. *Limnologia*, **28**: 387–393.
 28. Zahran, M.A., Serag, M.S. and Björk, S. (1998) On the ecology of aquatic plants of the irrigation and drainage canals of Damietta, Egypt. *J. Envir. Sci. Mansoura Univ.*,. **16**: 77 – 91.
 29. El-Hennawy, M.T. (1999) Ecological studies on aquatic hydrophytes in Dakahlia and Damietta. M.Sc. Thesis, Fac. Sci., (New Damietta) Mansoura Univ., Egypt..
 30. Serag, M.S.; Khedr, A.A.; Zahran, M.A. (1999) and Willis, A.J. Ecology of some aquatic plants in polluted water courses, Nile Delta, Egypt. *Proc. 6th International Conf. J. Union Arab Biol.*,. **9(B)**: p. 85 – 97.
 31. Serag, M. S. (2000) The Discovery of the papyrus (*Cyperus papyrus* L.) on the bank of Damietta Branch, Nile Delta, Egypt. *Tackholmia*,. **20**: 195–198.
 32. El-Amier, Y.A. and Al-Mamory, S.H. (2016). Macrophytic vegetation-environment relationship along Rosetta branch of the river Nile in Egypt. *Journal of Environmental Sciences, Mansoura University*, **45**: p. 299–314.
 33. El-Amier, Y.A. and Abd El-Gawad, A.M. (2017) Plant communities along the international coastal highway of Nile

- delta, Egypt. *Journal of Science Agriculture*, **1**: p.117-131.
34. El-Amier, Y.A., Zahran, M.A., Al-Mamoori, S.O. (2015). Plant Diversity of the Damietta Branch, River Nile, Egypt: An Ecological Insight. *Mesopotamia Environmental Journal*, **1**: p. 109-129.
 35. El-Amier, Y.A., Bonanomi, G., Al-Rowaily, S.L. and Abd-ElGawad, A.M. (2020) Ecological Risk Assessment of Heavy Metals along Three Main Drains in Nile Delta and Potential Phytoremediation by Macrophyte Plants. *Plants*, **9**(7), p.910.
 36. El-Shazly, M.M., Omar, W.A., Edmardash, Y.A., Ibrahim, M.S., Elzayat, E.I., El-Sebeay, I.I., Abdel Rahman, K.M., Soliman, M.M. (2017). Area reduction and trace element pollution in Nile Delta wetland ecosystems. *Afri. J. Eco.*, **55** (4), 391–401.
 37. El Kafrawy, S.B., Bek, M.A., Negm, A.M. (2018). An overview of the Egyptian northern coastal lakes. In: *Egyptian Coastal Lakes and Wetlands: Part I*. Springer, Cham, pp. 3–17.
 38. Westhoff, V. and Van der Maarel, E. (1973). The Bruan-Blanquet approach. In: Whittaker, R.H. (ed) *Handbook of vegetation science*. V. Ordination and classification of vegetation: 619 – 729. Dr. W. Junk, The Hague.
 39. Mueller-Dombois, D. and Ellenberg, H. *Aims (1974) and Methods of Vegetation Ecology*. John Wiley and Sons, New York, Chichester, Brisbane, Toronto..
 40. Raunkiaer, C. (1934). *The life forms of plants and statistical plant geography*. Translated by Carter, Fausboll and Tansley, Oxford Univ. Press, London.
 41. Raunkiaer, C (1937). *Plant Life Forms*. Clarendon, Oxford..
 42. Tutin, T.G.; Heywood, V.H.; Burges, N.A.; Moore, D.M.; Valentine, D.H.; Walters, S.M. and Webb, D.A (1964-1980). *Flora Europaea*. Vols. **1-5**, Cambridge Univ. Press..
 43. Davis, P.H. (1965-1985) *Flora of Turkey and the East Aegean Islands*. Vols. **1-9**, Edinburgh Univ. Press..
 44. Zohary, M. (1966 - 1972) *Flora Palaestina*. Vols. **1** and **2**. The Israel Academy of Science and Humanities, Jerusalem..
 45. Tackholm, V (1974). *Students' flora of Egypt*. 2nd edition, Cairo Univ. Press..
 46. Meikle, R.D. (1977 & 1985) *Flora of Cyprus*. Vols. **1** and **2**. Bentham-Maxon Trust, Royal Botanic Gardens, Kew..
 47. Feinbrun-Dothan, N. (1978 - 1986) *Flora Palaestina*, Vol. **3** and **4**. The Israel Academy of Science and Humanities, Jerusalem..
 48. Boulos, L. (1995 – 2005) *Flora of Egypt*. Vols. **1**, **2**, **3**, and **4**, All Hadara Publishing, Cairo, Egypt..
 49. El-Sheikh, M.A. (1996). *Ruderal plant communities of the Nile Delta region*. Ph.D. Thesis, Faculty of Science, Tanta University,
 50. Shaltout, K.H., Hassan L.M. and Farahat, E.A. (2005) *Vegetation-environment relationships in south Nile delta*. *Taeckholmia*, **25**: p. 15- 46.
 51. Shaltout, K.H., Sharaf El-Din, A. and Ahmed, D.A. (2010). *Plant life in the Nile Delta*. Tanta University Press, Tanta, Egypt,
 52. Al-Mamoori, S.O. (2014) *Studied successive changes in the plant life of the Damietta branch, River Nile in Egypt: An Ecological Denotation*, M. Sc. Thesis, Faculty of Science Mansoura University, Egypt.
 53. Negbi, M. (1989) *Theophrastus on geophytes*. *Botanical Journal of the Linnean Society*, **100**: p. 15-43.
 54. Zahran, M.A. and Willis, A.J. (2009). *The vegetation of Egypt*. 2nd ed. Springer. Netherlands,
 55. Ayyad, M.A. El-Ghareeb, R. (1982) *Salt marsh vegetation of the Western Mediterranean Desert of Egypt*. *Vegetatio*, **49**: p. 3-19.
 56. Cain S.A. and Castro, G.M. (1959) *Manual of vegetation analysis*. Harper and Brothers, New York,.
 57. Zohary, M. (1962). *Plant Life of Palestine*. Ronald Press, New York,
 58. Quezel, P. (1978). *Analysis of the flora of Mediterranean and Saharan Africa, Phytogeography of Africa*. *Annals of the Missouri Botanical Garden*, **65**: p. 479-534.

59. Maswada, H.F. (2009) .Ecological and physiological studies on some geophytes in the Mediterranean Coastal region of Kafr El-Sheikh governorate, Egypt. Ph.D. Thesis, Faculty of Science, Tanta University Egypt,
60. El-Amier, Y.A. (2010) Phytosociological and Autecological studies on the canal bank vegetation in Egypt. PhD. Thesis, Faculty of Science Mansoura University, Egypt,.
61. El-Sheikh, M.A (1989).. A study of the vegetation environmental relationships of the canal banks of middle delta region. M.Sc. Thesis, Faculty of Science, Tanta University,
62. Al-Sodany, Y.M. (1992). Vegetation analysis of the Northern part of Nile Delta region. M.Sc. Thesis, Faculty of Science Tanta University, Egypt,
63. El-Halawany, E.F. (2003) Vegetation changes in North Nile Delta within two decades. *Journal of Environmental Science, Mansoura University*,. **26**: p. 153- 180.
64. Shalaby, M.A. (1995). Studies on plant life at Kafr El-Sheikh Province, Egypt. M.Sc. Thesis, Faculty of Agriculture, Kafr El-Sheikh, Tanta University, Egypt,
65. Awad, E.R. (2001). Ecological studies on the weed flora of the orchards in the Nile Delta and their nutritive potentialities. M. Sc. Thesis, Faculty of Science Mansoura University, Egypt.
66. Abd El-Ghani M.M. and Amer, A.M. (1990) Studies on weed assemblages in croplands, Egypt, I. Broad Bean Fields. *Egyptian Journal of Botany*,. **33**: p. 15-30.
67. El-Demerdash, M.A., Itosni, I.A., and El-Ashri, N. (1997) Distribution of the weed communities in the north east Nile Delta, Egypt. *Feddes Repertorium*,. **108**: p. 219-232.
68. El-Ameir, Y.A. (2005) Eco-palynological studies of the plant life of the River Nile in Egypt. M.Sc. Thesis, Faculty of Science, Mansoura University, Egypt,