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Floristic and ecological features of three drains in the North of Nile Delta of Egypt

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Abstract: The present study provides an investigation of the floristic and ecological features, in three drains in the North of Nile Delta, of Egypt. Thirty-two stands were distributed in three drains namely, Amar, El-Westany and Omar Beck. The frequency of each plant species was estimated. Soil and water analyses were carried out in each stand. Two Way Indicator Species Analysis (TWINSPAN) was applied to the frequency values of the recorded species. Thirty-six species belonging to 34 genera and 18 families were recorded. These species were classified into 19 annuals, 15 perennials and two biennials. Poaceae (22.1 %), Chenopodiaceae (13.8 %), Asteraceae, Brassicaceae (11.1 %) and Polygonaceae (5.5%) were the most represented families. TWINSPAN allowed to identifying three plant groups: (A): Typha domingensis, (B): Phragmites australis and (C): Phragmites australis. In our study, Canonical Correspondences Analysis (CCA) of both hydrosoil and water variables highlighted the importance of the organic matter, salinity (sodium, chloride and electric conductivity) and pH for the floristic composition. In soil and water, the concentrations of heavy metals take the following accumulation order: Fe> Mn> Zn> Pb> Cu> Cd> Co, where El-Westany Drain had the highest concentrations and the lowest concentrations were recorded at Omr Beck Drain. The concentration of heavy metals in water samples was above the standard level of the Egyptian Environmental Affairs Agency. Therefore, it is crucial to establish a treatment water station if possible.

keywords: drains, life forms, multivariate analysis, hydrophytes, water quality.

1.Introduction

In many African countries, significant population growth co-occurred by industrial, and agricultural land use has led to an incredible raise in the discharge of several pollutants to receiving water bodies and has produced unfavorable effects on components of aquatic environment [1]. Moreover, recent agricultural activities have launched numerous polluting substances such as chemical fertilizers, organic matter, and herbicides into the Nile River and irrigations- drainage systems [2].

In Egypt, the canals and drains are infested by aquatic weeds. The degree of infestation is affected by environmental factors, including water transparency, depth of water, physic-chemical properties, water quality, water currents and air temperature. Problems in Egyptian irrigation canals have increased since 1965 as a result of building of Aswan High Dam [3]. The main problems of the drainage canals are the existence of high concentrations of heavy metals and pesticides in the water and fish organs [2].

The total length of the drainage canals in Egypt is 16,231 km [4, 5]. The major source for metals in irrigation and drainage canals is the discharge of domestic wastewaters which have high concentrations of metals, where these metals are originated from household stuffs such as cosmetics, toothpaste, and human faeces, etc. [6]. Also, there are additional quantities introduced from industrial wastes illegally discharged into canals through washing of herbicides and pesticides of the agricultural lands [7].

The main objectives of the present work were to investigate the floristic features of three polluted drains in the Nile Delta region, Egypt and determine the main environmental drivers that affect the floristic structure for the plant groups in study area.

2. Materials and methods

2.1 Study area

Thirty-two stands were located in the Nile Delta region of Egypt and distributed along three drains; El-Westany, Amar and Omar Beck (Figure 1). These drains represented three governorates Damietta, El-Dakahlia and El-Gharbia, respectively. Climatically, the Nile Delta is located in the coastal sector of the arid province with hot summers and mild winters [8]. The annual mean temperature varied from 19 to 24 °C while annual rainfall ranges between 9 and 15 mm.

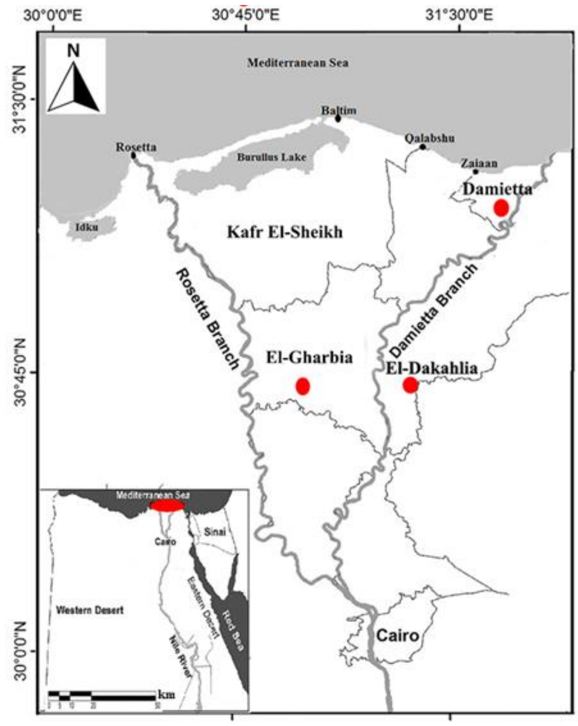

Figure 1. Map of Egypt shows the study areain the Nile Delta region (red circles).

2.2 Floristic sampling

Thirty-two stands were selected randomly for sampling as follow: 12 stands in Amar Drain (El-Dakahlia Governorate), nine stands in El-Westany Drain (Damietta Governorate) and 11 stands in Omr Beck Drain (El-Gharbia Governorate). In each stand, GPS coordinates and plant species list were recorded and frequency of each plant species was determined. Life-forms were recognized according to [9]. The classification, identification and floristic categories were according to [10, 11, 12]. Voucher plant specimens were kept at the Herbarium of Mansoura University, Egypt.

2.3 Soil and water analyses

Three soil samples were composed at a profile of 0-50 cm from each stand. Organic carbon was determined using Walkley-Black method [13]. Electric pH-meter was used to determine the soil reaction in 1:5 soil extract. Electric conductivity (EC) was measured by the conductivity meter (Apera AI209 model). HCO_3, Cl, SO_4, total dissolved phosphorus (TDP) and total nitrogen (TN) were estimated according to USDA/NRCS manual [13]. Na^+ and K^+ were determined using a flame photometer (Hanchen FP model) while Ca^{2+}, Mg^{+2} and heavy metals (Fe, Mn, Zn, Cu, Co, Cd and Pb) were analysed by an atomic absorption spectrophotometer (A Perkin-Elmer, USA) [13].

Water samples were also collected from each stand in the studied drains in polyethylene bottles. All of the previously chemical analyses of the soils samples were also estimated in the water samples according to USDA/NRCS manual [13]. Significance in soil and water variables among the identified groups was tested using the ANOVA/Kruskal-Wallis test in XLSTAT v. 2016 program.

2.4 Data analysis

Two trends of multivariate analysis were applied to the frequency estimates of the recorded species in the 32 stands in the present study: TWINSPAN as a classification technique, and the Detrended Correspondence Analysis (DCA) as an ordination one [14, 15]. The relationship between the plant groups and soil and water variables was assessed using the Canonical Correspondence Analysis (CCA) [16]. All statistical analyses were done using XLSTAT 2016.

3. Results and Discussion

1.1. Floristic features

The total number of the recorded species was 36 belonging to 34 genera and 18 families (Table 1). Out of these families, Poaceae comprises 8 species (22.1%), followed by Chenopodiaceae with 5 species (13.8%), Asteraceae and Brassicaceae with 4 species each (11.1%), Polygonaceae with 2 species (5.5%), while the other remaining families were represented by only one species each (2.8%). Regarding the life-span, the recorded species were distinguished into 19 annuals (52.8%), 15 perennials (41.7%) and two biennials (5.5%). Regarding the life forms, therophytes had the highest representation (21 species, 58.3%), followed by cryptophytes (13 species, 36.1%), then hemicryptophytes and nano-phanerophytes with two species each (2 species, 5.5%). The global floristic analysis revealed that 50 % of the total number of the surveyed species was worldwide taxa. These species were either pluri-regional (10 species, 27.8%), bi-regional (6 species, 16.7%) or mono-regional (one species, 2.8%). In addition, 50% of the recorded species were either cosmopolitan (8 species, 22.2%), pantropical (6 species, 16.7%), palaeotropical (3 species, 5.5%), or neotropical (one species, 2.8%).

Ann: annuals; Per: perennials; Bie: biennials; Th: therophytes; H: hemicryptophytes; Nph: nano-phanerophytes; G: geophytes; Hy: hydrophytes; He: Helophytes; ME: Mediterranean; SA-SI: Saharo-Sindian; IR-TR: Irano-Turanian; S-Z: Sudano-Zambezian; ER-SR: Euro-Siberian; PAL: Palaeotropical; COSM: Cosmopolitan; PAN: Pantropical; NEO: Neotropical; CULT and NAT: Cultivated and Naturalized.

The application of TWINSPAN led to the detection of three vegetation/plant groups (A, B and C) at the 3rd level (Figure 2). Subsequently, DCA displayed a sensible separation among these groups along the ordination axes 1 and 2 (Figure 3). The three plant groups were named after the first species with the highest frequency in each group as follow: A: *Typha domingensis*, B: *Phragmites australis* and C: *Phragmites australis*. Group A includes two stands, group B had 18 stands and group C had 12 stands. The most common associated species in group A which attained high frequency values were *Sonchus oleraceus*, *Cynodon dactylon*, *Cyperus alopecuroides* and *Malva parviflora*. On the other hand, the most common and indicator species in group B include *Rumex dentatus*, *Chenopodium murale*, *Echinochloa stagnina*, *Eichhornia crassipes*, *Ranunculus sceleratus* and *Malva parviflora*. For group C, *Rumex dentatus*, *Ranunculus sceleratus*, *Eichhornia crassipes* and *Echinochloa stagnina* were the most common associated and indicator species.

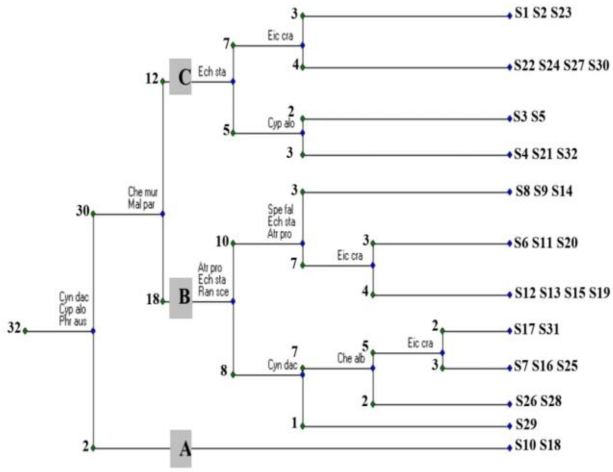

Figure 2. Dendrogram of the three vegetation groups derived after TWINSPAN, based on the 32 sampled stands (S1-S32). A, B and C are the vegetation groups.

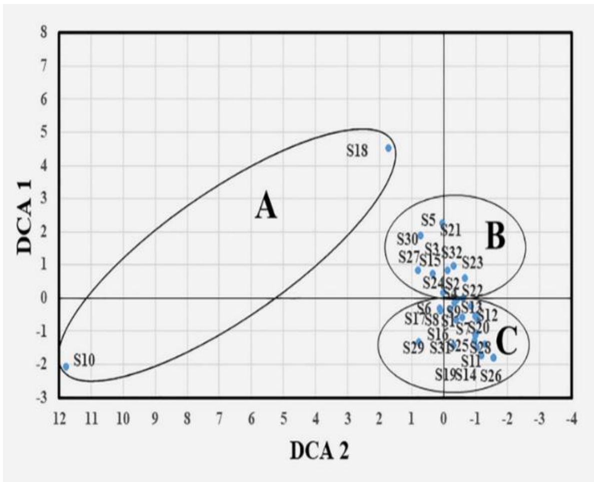

Figure 3. The three vegetation groups (A, B and C) derived from DCA ordination analysis.

1.2. Relationship between plant groups and soil and water variables

The soil and water variables (mean values±standard error) of the three vegetation groups were displayed in Table 2. Soil analysis displayed that, Cl, Na and Mn were significantly differed in the three groups. Soils of group A had the highest contents of EC, OC, HCO_3, Cl, SO_4, TDP, Na, K, Ca, Mg, Fe, Mn, Cu, Co, Cd and Pb (Table 2). Soils of group B attained the highest values of pH, TN, Zn and Cd.

Regarding water analysis, EC, OC, HCO_3, Cl, SO_4, Na, K, Ca, Mg, Fe, Mn and Pb were significantly different ($p< 0.05$) among vegetation groups. Water samples of group A had the highest values of all variables except pH and TN.

Table (1). Plant species composition of the study area with their families, life-forms, life-span and chorotypes.

Families and plant species	**Life span**	**Life form**	**Chorotype**
Amaranthaceae			
Alternanthera sessilis (L.)DC.	Per.	He	PAN
Asteraceae (Compositae)			
Pluchea dioscoridis (L.) DC.	Per.	Nph	S-Z+SA-SI
Senecio glaucus L.	Ann.	Th	ME+SA-SI+IR-TR
Silybum marianum (L.) Gaertn.	Ann.	Th	ME+IR-TR+ER-SR
Sonchus oleraceus L.	Ann.	Th	COSM
Brassicaceae (Cruciferae)			
Brassica nigra (L.) Koch	Ann.	Th	COSM
Cakile maritima Scop.	Ann.	Th	ME+ER-SR
Raphanus raphanistrum L.	Ann.	Th	ME+ER-SR
Rorippa palustris (L.) Besser.	Bie.	Th	ER-SR+IR-TR+ME
Caryophyllaceae			
Spergula fallax (Lowe) E. H. L. Krause.	Ann.	Th	SA-SI+ME+S-Z
Chenopodiaceae			
Atriplex prostrata Boucher ex DC.	Ann.	Th	ME+ER-SR+IR-TR
Bassia indica (Wight) A. J. Scott.	Ann.	Th	S-Z+IR-TR
Beta vulgaris L.	Bie.	Th	ME+IR-TR+ER-SR
Chenopodium album L.	Ann.	Th	COSM
Convolvulaceae			
Convolvulus arvensis L.	Per.	H	COSM
Cyperaceae			
Cyperus alopecuroides Rottb.	Per.	He	PAN
Euphorbiaceae			
Ricinus communis L.	Per.	Nph	CULT and NAT
Fabaceae (Leguminosae)			
Melilotus indicus (L.)All.	Ann.	Th	ME+IR-TR+SA-SI
Malvaceae			
Malva parviflora L.	Ann.	Th	ME+IR-TR
Onagraceae			
Ludwigia stolonifera (Guill. & perr.) P.H.Raven	Per.	He	S-Z
Poaceae (Gramineae)			
Cynodon dactylon (L.) Pers.	Per.	G	PAN
Echinochloa crusgalli (L.) P. Beauv.	Ann.	Th	PAN
Echinochloa stagnina (Retz.) P.Beauv.	Per.	G,He	PAL
Hordeum marinum Huds.	Ann.	Th	ME+IR-TR+ER-SR
Imperata cylindrica (L.) Raeusch.	Per.	H	ME+PAL
Panicum repens L.	Per.	G	PAN
Phragmites australis (Cav.) Trin. ex Steud.	Per.	G,He	COSM
Polypogon monspeliensis (L.) Desf.	Ann.	Th	COSM
Polygonaceae			
Persicaria salicifolia (Brouss. ex Willd.) Assenov	Per.	G	PAL
Rumex dentatus L.	Ann.	Th	ME+IR-TR+ER-SR
Pontederiaceae			
Eichhornia crassipes (C. Mart.) Solms.	Per.	Hy	NEO
Ranunculaceae			
Ranunculus sceleratus L.	Ann.	Th	ME+IR-TR+ER-SR
Scrophulariaceae			
Veronica anagallis –aquatica L.	Per.	He	COSM
Solanaceae			
Solanum nigrum L.	Ann.	Th	COSM
Typhaceae			
Typha domingensis (Pers.) Poir. ex Steud.	Per.	He	PAN

Table (2). Mean± standard error of the soil and water characteristics in relation to three vegetation groups. Highlighted different letters in the same row are significantly different at $p< 0.05$.

Variable	Vegetation group			Variable			
	A	B	C		A	B	C
	Hydrosoil				Water		
pH	8.12 ± 0.05^{a}	8.21 ± 1.94^{a}	8.18 ± 0.04^{a}	pH	7.77 ± 0.07^{a}	7.85 ± 1.85^{a}	7.78 ± 0.04^{a}
EC (dSm^{-1})	5.90 ± 0.54^{a}	5.64 ± 1.40^{a}	5.52 ± 0.25^{a}	EC (dSm^{-1})	6.02 ± 0.39^{b}	5.11 ± 1.44^{a}	4.87 ± 0.19^{ab}
OC (%)	1.21 ± 0.05^{a}	1.08 ± 0.29^{a}	1.04 ± 0.03^{a}	OC (meq/l)	11.93 ± 0.8^{a}	10.15 ± 2.84^{b}	9.67 ± 0.37^{ab}
HCO_3(meq/100g)	5.92 ± 0.52^{a}	5.08 ± 1.35^{a}	5.67 ± 2.21^{a}	HCO_3 (meq/l)	12.07 ± 0.82^{b}	10.32 ± 2.87^{a}	9.82 ± 0.37^{ab}
Cl^- (meq/100g)	18.08 ± 1.64^{b}	14.31 ± 4.50^{a}	11.05 ± 1.77^{ab}	Cl^- (meq/l)	35.4 ± 2.7^{a}	30.22 ± 3.71^{b}	29.28 ± 1.17^{ab}
SO_4 (meq/100g)	6.21 ± 0.61^{a}	5.46 ± 1.33^{a}	5.22 ± 0.22^{a}	SO_4 (meq/l)	12.75 ± 0.36^{b}	10.61 ± 2.82^{a}	9.61 ± 0.51^{ab}
TDP (mg/kg)	4.64 ± 0.10^{a}	4.45 ± 1.20^{a}	4.42 ± 0.13^{a}	TDP (meq/l)	1.17 ± 0.02^{a}	1.10 ± 0.30^{a}	1.07 ± 0.03^{a}
TN (mg/kg)	31.21 ± 0.93^{a}	31.70 ± 1.19^{a}	31.08 ± 0.59^{a}	TN (meq/l)	7.13 ± 0.55^{a}	7.33 ± 1.54^{a}	6.95 ± 0.18^{a}
Na^+ (meq/100g)	17.94 ± 1.6^{a}	15.61 ± 4.44^{b}	12.10 ± 0.85^{ab}	Na^+ (meq/l)	1.84 ± 0.11^{a}	1.53 ± 0.44^{a}	1.48 ± 0.06^{b}
K^+ (meq/100g)	1.56 ± 0.16^{a}	1.38 ± 0.33^{a}	1.29 ± 0.09^{a}	K^+ (meq/l)	60.2 ± 3.9^{b}	51.10 ± 4.38^{a}	48.7 ± 1.94^{ab}
Ca^{++} (meq/100g)	6.09 ± 0.53^{b}	5.68 ± 1.40^{a}	5.6 ± 0.25^{a}	Ca^{++} (meq/l)	9.44 ± 0.38^{b}	7.70 ± 2.20^{a}	6.82 ± 0.34^{ab}
Mg^{++} (meq/100g)	4.62 ± 0.48^{a}	4.18 ± 1.0^{a}	3.94 ± 0.25^{a}	Mg^{++} (meq/l)	37.0 ± 2.6^{b}	31.72 ± 8.9^{a}	30.74 ± 1.23^{ab}
Fe (meq/100g)	2.92 ± 0.14^{a}	2.81 ± 0.68^{a}	2.68 ± 0.04^{a}	Fe (meq/l)	1.03 ± 0.02^{b}	0.94 ± 0.25^{a}	0.88 ± 0.04^{ab}
Mn (meq/100g)	2.60 ± 0.55^{a}	2.20 ± 0.49^{a}	1.98 ± 0.02^{b}	Mn (meq/l)	0.78 ± 0.09^{a}	0.72 ± 0.17^{a}	0.65 ± 0.03^{b}
Zn (meq/ 100g)	1.22 ± 0.02^{a}	1.25 ± 0.28^{a}	1.23 ± 0.01^{a}	Zn (meq/l)	0.52 ± 0.03^{b}	0.48 ± 0.13^{a}	0.46 ± 0.02^{a}
Cu (meq/100g)	0.51 ± 0.06^{a}	0.50 ± 0.13^{a}	0.46 ± 0.01^{a}	Cu (meq/l)	0.15 ± 0.04^{a}	0.14 ± 0.04^{a}	0.14 ± 0.01^{a}
Co (meq/100g)	0.21 ± 0.0^{a}	0.20 ± 0.05^{a}	0.18 ± 0.01^{a}	Co (meq/l)	0.10 ± 0.01^{a}	0.09 ± 0.03^{a}	0.08 ± 0.01^{a}
Cd (meq/100g)	0.33 ± 0.0^{a}	0.33 ± 0.08^{a}	0.32 ± 0.01^{a}	Cd (meq/l)	0.15 ± 0.02^{a}	0.13 ± 0.03^{a}	0.13 ± 0.01^{a}
Pb (meq/100g)	0.80 ± 0.01^{a}	0.77 ± 0.19^{a}	0.74 ± 0.01^{a}	Pb (meq/l)	0.23 ± 0.01^{a}	0.21 ± 0.06^{a}	0.19 ± 0.02^{b}

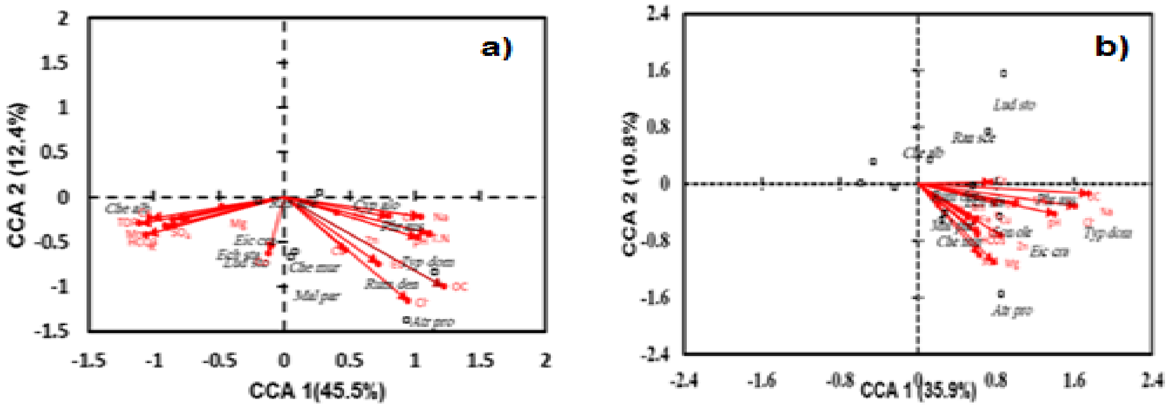

Figure 4. The CCA diagram of the dominant, most common associated and indicator species a. via hydrosoil factors, and b. via water variables

The CCA diagram of the dominant, most common associated and indicator species x hydrosoil factors and water variables is represented in Figure (4 a, b). The CCA of species and hydrosoil results displayed that, the best parsimonious model with significant hydrosoil variables included OC, Cl, Na, EC, pH and TN (Figure 4a). Soil organic carbon (OC) and electric conductivity (EC) had a strong effect on plant group A, while *Phragmites australis* which was the dominant species in groups B and C was correlated with Na, TN and pH. On the other hand, CCA of species and water variables elucidated that, OC, Na, Cl, pH and TN were the most significant variables affecting the distribution of the plant species with groups (Figure 4b).

The species were abbreviated as follow: Cyp alo: Cyperus alopecuroides, Phr aus: Phragmites australis, Typ dom: Typha domingensis, Rum den: Rumex dentatus, Atr pro: Atriplex prostrata, Che mur: Chenopodium murale, Mal par: Malva parviflora, Eic cra:

Eichhornia crassipes, Ech sta: Echinochloa stagnina, Lud sto: Ludwigia stolonifera, Ran sce: Ranunculus sceleratus and Che alb: Chenopodium album.

Discussion

The recorded species in the present study (36 species) represent ca. 7% of the whole flora of the Nile region (534 species) [8]. The low number of species in the study area may be due to water pollution, weed control, waste discharge and high specificity of aquatic species. Moreover, the extensive growth of *Phragmites austarlis* on the canal and drain banks reduce the germination and growth of other species [17]. Poaceae, Chenopodiaceae, Asteraceae, Brassicaceae and Polygonaceae were the prominent families in the studied drains. This finding agrees with [18] on the canal drain vegetation of the middle Nile Delta region. Therophytes were the utmost common life form followed by cryptophytes. This is completely harmonizing with the life forms of the flora of the Nile Delta [8]. The preponderance of therophytes is attributed to hot climate, topography and biotic impacts [19]. In addition, the high frequency of cryptophytes as an active life form in the present area could be related to certain features of both their growth habit and the nature of the soil. Most of the recorded cryptophytes are rhizomatous species this is an advantage for their successful growth and distribution [20]. The Mediterranean taxa were represented by a high percentage (50%). This finding is previously confirmed for the flora of Egypt by [21].

The floristic composition in the study area was classified into three vegetation/plant groups (A, B and C) using TWINSPAN. Each group constitutes a specific number of stands that are similar in dominant, codominant and indicator species. The discriminated groups represent hydric and/or canal bank habitats. Group A represents the habitat type of both Amar and El-Westany drains while groups B and C represent the habitats of the three drains (Amar, El-Westany and Omar Beck). Group A was dominated by *Typha domingensis* while groups B and C were dominated by *Phragmites australis*. In general, the behavior and distribution of hydrophytes are affected by water quality [22]. The dominance of these species over the other species may be attributed to their rhizomatous stem and their resistance to decomposition under constant submergence. Moreover, these species prefer low saline habitat and littoral and water zones of drains [8]. Many studies proved the potentiality of emergent macrophytes such as *Phragmites austarlis* and *Typha domingensis* as water purifiers/phytoremediators [23, 24, 25].

Several previous studies have displayed that, the floristic composition in Nile Delta region are linked to water conditions, soil salinity and soil fertility (total nitrogen and phosphorous) and pH [17; 26-29]. In our study, CCA for both hydrosoil and water variables highlighted the importance of organic matter, salinity (Na, Cl and EC) and pH for the floristic composition. The soils were mostly alkaline; with pH values greater than 7 in all examined hydrosoil drain. This inherent soil alkalinity is typical of the arid climatic conditions and partly attributed to the dominance of Na^{+} over the other cations (Ca^{+2}, Mg^{+2}, and K^{+}) in the soils of Nile Delta [30]. The supply of organic carbon (OC) is sufficient for agricultural production under the aridity conditions. Electric conductivity (EC), attained the highest value in Omar Beck Drain, followed by an intermediate value in El-Westany Drain and the lowest value in Amar Drain. This could be mainly attributed to that the soil under the practice is not intermittently flooded; thus, little dilution of salt [30]. The rise in soil salinity of drain banks as compared with those of irrigation canals is due to the drained water is usually more saline than the irrigation water [31].

The concentrations of heavy metals in the soil of the three drains take the following accumulation order: Fe> Mn> Zn> Pb> Cu> Cd> Co, where El-Westany Drain recorded the highest concentrations of these heavy metals, followed by Amar Drain, and the lowest concentrations were recorded at Omr Beck Drain. Fe was the most accumulated element in soil, whereas Co was found to be the least concentration. This is agreed with [32]. The highest concentrations of Fe and Zn were noted in El-Westany Drain as a result of industrial activities at Damietta Governorate; this is in agreement with [33]. Also, the rise of organic matter enables the accumulation of Fe in sediment [34]. The highest value of Mn was obtained in El-Westany Drain; this could be attributed to the agricultural drainage water source. The concentration of Pb increases in El-Westany Drain than other drains may due to the agricultural drainage water or the deposition of dead planktons that increase its amount in the sediments, this agreed with [35] who found the same observation. Copper was high in El-Westany Drain that characterized by a high clay percentage content, where there is a significant correlation between copper and fine-grained clay particles which contained more metals than coarse-grained sand and also due to industrial disposal [36]. Co and Cd in the soil samples showed high concentrations especially in El-Westany Drain as it is mostly correlated to phosphate fertilizers [37].

For water characterization, the highest value of EC values was attained in El-Westany Drain. This attributed to drainage water in this area come from the land runoff which contains large amounts of cations and anions [38]. It was observed that the range of pH exhibited the highest value in El-Westany Drain and the lowest one in Omar Beck Drain (7.7), which indicated neutral to slight-alkaline, could be related to photosynthesis and growth of aquatic plants, where photosynthesis consumes CO_2 leads to arise in the pH values. However, natural water tends to be alkaline because of carbonates and bicarbonates. The values of pH are within the Egyptian law [39].

The use of phosphate fertilizers tends to increase the phosphorus content in water. Phosphates play a role in plant and animal metabolism and thus occur in their waste products. Domestic detergent and industrial sewage effluents represent important sources of phosphorus in natural water. High concentrations of nutrients (i.e. TP and TN) can cause many problems to water quality such as; acidification, eutrophication and impairing the aquatic organisms to survive or grow [40]. The lowest values of TP and TN were recorded in Omar Beck Drain, while the highest values were recorded in El-Westany Drain. High values of TP and TN are associated with agricultural wastes [41]. It was observed that El-Westany Drain showed the highest values of SO_4, and HCO_3 while Omar Beck Drain had the lowest values. It is important to measure chlorides as it expressed the quality of water. El-Westany Drain showed the highest value of chlorides while Omar Beck Drain exhibited the lowest value. These values are not within the FAO guidelines that suggested that the permissible limit of chlorides is 7-12 mg/L. Therefore, the water of the three drains is unsuitable and has a harmful effect on the vegetables and crops [42].

Heavy metal pollution in water is generally associated with agricultural, industrial and municipal discharges into water resources. The concentrations of heavy metals in water take the following sequence: Fe> Mn> Zn> Pb> Cu> Cd> Co. The highest concentration of heavy metals was recorded in El-Westany Drain nearby drainage wastewater especially industrial wastes. These results are in concurrence with those obtained by [33] who reported that the high concentrations of heavy metals may be due to the waste waters from different industrial activities without treatment.

In conclusion, *Phragmites australis* and *Typha domingensis* were the most dominant species in the study area. CCA for both hydrosoil and water variables highlighted the importance of organic matter, salinity (Na, Cl and EC) and pH for the floristic composition. The concentrations of heavy metals in the soil of the three drains take the following accumulation order: Fe> Mn> Zn> Pb> Cu> Cd> Co, where El-Westany Drain had the highest concentrations of these metals and the lowest concentrations were recorded at Omr Beck Drain. Finally, the authors recommend the establishment of a station for treatment of polluted water at El-Westany drain, if possible.

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