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Environmental drivers for the distribution of *Najas marina* L. subsp. *armata* in Lake Burullus, Egypt

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ABSTRACT

Najas marina L. subsp. *armata* (Lindb.f.) Horn, family Najadaceae, which called Horreish in Egypt, is a submerged aquatic plant, inhabits fresh or brackish water. The plant collected from Nasser Lake (Egypt), dried, and kept to be used later as a vital source of fodder for sheep and goats in dry periods as it is offered in local markets as food in Hawaii. This work is the first study on *N. marina* in the Nile Delta of Egypt as the global studies were rare and outdated. The ultimate goal of this work is to specify the environmental agents (water and sediment) controlling the *N. marina* distribution in Lake Burullus, identify the plant communities associated with *N. marina*, and assess the plants-environmental agents' relationship. Results obtained by Canonical Correspondence Analysis (CCA) indicated that the major efficacious environmental agents (water and sediment) that affect the distribution of *N. marina* in Lake Burullus, were salinity factors as, EC, TDS, Cl^-, HCO_3^- and some elements as Na^+ and Mg^{++} as well as nutrients (TN and TP). The analysis of Two Way Indicator Species Analysis (TWINSPAN) revealed six clusters (A-F); the indicator species were as follow, cluster A, *Arthrocnemum macrostachyum*; cluster B, *Juncus acutus*; cluster C, *Suaeda vera*; cluster D, *Potamogeton pectinatus*; cluster E, *N. marina*; cluster F, *Phragmites australis*. In addition, CCA analysis showed that there is a positive relationship between *N. marina* distribution and nutrients agents, but a negative relationship between the target plant and salinity agents. The studied locations in the north section were higher in salinity than that of the southern locations. It worth mentioning that the plant was disappeared from El Kom El Akhdar where the EC value was 13.7 mS/cm and TDS was 7.6 mg/l. Also, the plant was not found in the northeastern section, where the fishermen reported that the opening of Al-Bughaz increases the water salinity, and *N. marina* not found. Generally, the reciprocal relationship of plants-environment is embedded in all living systems, which are the fundamental basis for the various types of sustainable improvement, especially the essential basis for water sustainable development. Community features of the aquatic plants are essential indicators for water quality.

INTRODUCTION

It is essential for both ultimate and applied ecological studies to understand the environmental factors structuring biological communities **(Jackson *et al.*, 2001; Ricklefs, 2004)**. For keeping up the continuous universal change, the necessity for reliable data on the relationships between species richness-environment as well as species composition - environment has augmented. It is very necessary to understand how various environmental agents drive the distribution of species and ecological communities and how biota is further influenced by changes in these variables **(McGill *et al*., 2015 and Alahuhta *et al*., 2019)**.

Lake habitats are pivotal resources for aquatic fauna and human requests, so any changes in their environmental quality has extensive ecological and societal inferences **(Vincent, 2009)**. These habitats featured by their richness, profitable and interactive ecosystems over the world **(Rangnekar, 2016)**. Burullus Lake is the second largest natural lake in Egypt, which is a part of the deltaic Mediterranean coast, connected to the Mediterranean Sea through a natural outlet (Al-Bughaz). This lake is featured by elevated growth of hydophytes **(El-Kady, 2000 and Shaltout and Khalil, 2005)**.

Macrophytes are aquatic plants, growing in or near water that are emergent, submerged or floating. Macrophytes provide lakes with several serves like those that act as settler for fish, food and fodder sources, as water quality monitor and have an important role in the maintenance of some functions (*e.g.* nutrient cycles and heavy metals removal) of the aquatic habitat **(Robach *et al*., 1996; El-Sherbeny *et al*., 2015; El-Sherbeny and Ramadan, 2016)**.

Najas marina L. subsp. *armata* (Lindb.f.) Horn belongs to family Najadaceae called Spiny naiad, Spiny waternymph and in Egypt called Horreish. It is a submersed plant which has fragile stems that break easily, but can then generate roots and grow into a new plant that typically has prominent, brownish, prickly teeth in the stem **(Vierssen, 1982 and Stuckey, 1985)**. It forms aggressive mats that choke out other species, where it inhabits fresh or brackish water as Ponds, lakes, slow-moving streams and canals. The plant fertilization occur below the water surface as well as it is dioecious plant **(Stuckey, 1985 and Holm *et al*., 1997)**. *N. marina* is plant of the tropical to temperate zones, native in Egypt, common in Africa, mainly in coastal areas and Lake Crevice. *N. marina* is offered in local markets and used as food in Hawaii. In Egypt, it is collected from Nasser Lake, dried and kept to be used later as vital source of fodder for sheep and goats in dry periods **(Yacoub, 2009)**. In addition, the plant can help in maintaining the soil moisture, so it promotes early grass growth **(Belal *et al*., 2009)**. Macrophytes play key functions in biochemical cycles, for example, organic carbon production, phosphorous mobilization and the transfer of other trace elements **(Jeppesen *et al*., 1998; Paillisson and Marion, 2002)**.

Studies on *N. marina* are rare and focused on the plant and other species relationship more than plant-environment relationship as that carried out by **Agami and Waise (1985 & 2002)**. In Egypt, **Yacoub (2009)** studied the distribution *Najas* spp in Wadi Allaqi. Understanding the mutual interaction between the aquatic environment and macrophytes is essential, particularly if the macrophytes community includes a rare or highly valued (environmentally and/or economically) species. So this study carried out to a) specify the environmental agents (water and sediment) controlling the *N. marina* distribution in Lake Burullus b) identify the plant communities associated to *N. marina* and c) assess the plants-environmental agents relationship.

MATERIALS AND METHODS

1- Sampling locations

Burullus Lake is one from the Egyptian northern lakes that linked to the Mediterranean Sea through a way out called Al-Bughaz. It is located among 30º 30´ and 31º 10´ E longitudes and 31º 21´ and 31º 35´ N latitudes as indicated in Fig. 1. It expands for a distance of 47 km over the NE-SW axis with width fluctuates between 4 and 14 Km and area of 410 km^2. The depth of the lake varieties from 0.40 to 2.0 meters. Lake Burullus is situated in an arid province which characterized by warm summer (20–30 ^{0}C) and mild winter (10–20 ^{0}C). This lake is one of the largest areas that receive a huge amount of agricultural drainage water in Egypt, where it receives about 4 billion m^3 per year **(Shaltout and Khalil, 2005; Shaltout, 2018)**.

2- Selection of stands

Field studies were beginning with a survey for seeking the *Najas marina* plant at the Lake Burullus during November and November 2019, depending on the previous studies of the Lake **(Shaltout and Galal, 2006 and Shaltout and Al-Sodany, 2008)** and asking the fishermen. Beginning from Baltim, Al-Bughaz, El Robaa, Sook ElTalat, etc…. at the north eastern part, the plant was not found at this eastern section when we asked the fishermen, they reported that since Al-Bughaz was opened the salinity was increased and the plant was disappeared in this section. The plant collected from the south western section from Mastroh (location one), Abo Amer (location two), El Maksabah (loction Three) then from south of the lake at Deshimi (location four) (Fig. 1). The plant was also surveyed at El Kom El Akhdar, but it was not found, where EC detected was 13.7 mS/cm and TDS was 7.6 mg/l.

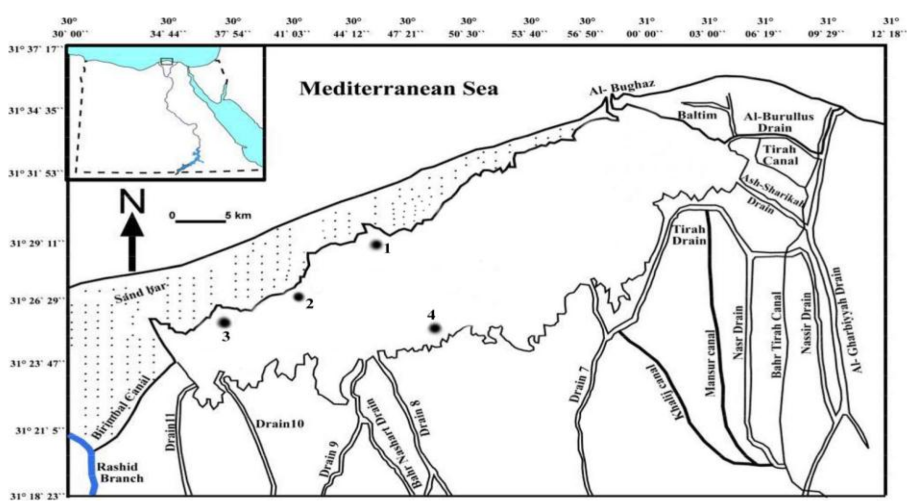

Figure (1): Map of Burullus Lake (Eid *et al*., 2020) revealed the selected Locations. Location 1, Mastroh; Location 2, Abo Amer; Location 3, Al Maksabah and Location 4, Deshimi.

Aquatic and terrestrial vegetation were recorded at 25 stands. In each stand, all plant species were recorded in five plots (area of each plot = 25 m^2) and then summed up to represent the stands. The frequency of each species was estimated at each stand

(Muller- Dombois and Ellenberg, 1974). In each stand the associated perennial and annual species as well as cover values were recorded on an eleven points Domin Scale according to **Westhoff & van der Maarel (1978)**. The relative values of frequency and cover were estimated for each plant species and summed up to determine the importance value (IV) in each stand out of 200. Voucher specimens were kept in the herbarium of the Botany Department, Mansoura University. Species identification recorded owing to **Tackholm (1974) and Boulos (2002&2009)**.

3- Sampling of water and sediment specimens

Water and sediment specimens were taken in triplicate from each studied site. The sediments were air dried and passed through a 2mm sieve to separate gravel and debris. The water specimens were collected as incorporated complex specimens from the water surface down to 20 cm, then taken in plastic container to the laboratory and filtered.

4- Chemical analysis

The water and sediment pH, Conductivity (mS/cm) and TDS (mg/l) were estimated by digital meter CONSORT Model C535. Determination of water and sediment carbonates (CO_3^{--}) and bicarbonates (HCO_3^-) by Piper (1947) as well as chlorides (Cl^-) in water and sediment samples were done as reported by Jackson (1962). The extractable cations sodium (Na^+), potassium (K^+) calcium (Ca^{++}), and magnesium (Mg^{++}) were determined in all water and sediment specimens by atomic absorption (Shimadzu AA-6200). The total nitrogen and total phosphorus were estimated in plant, water and sediment according to **APHA (1998)**. Sediment organic carbon was estimated by Walkely and Black rapid titration method **(Piper, 1947)**.

5- Statistical analysis

The vegetation data was classified with TWINSPAN (Two – Way Indicator species Analysis) according to **Hill (1979)**. This analysis affords a hierarchical divisive classification of the data matrix, where it represents the samples - species relationship within the data set. Canonical Correspondence Analysis (CCA) produce an ordination diagram of plant species - environmental agents using CANOCO: a FORTRAN program version 2.1 **(ter Braak, 1987)**. ANOVA (One-way analysis of variance) was used to evaluate the significance of variation in the environmental agents of vegetative clusters. This applied by Statistica 7.1 software **(Statsoft, 2007)**.

RESULTS

1- Vegetation analysis

Analysis of the studied sites revealed that the *Najas marina* subsp. *armata* (H. Lindb.) Horn plant was associated with nine associated species. All recorded associated species were perennials. An objective multivariate analysis was applied for a data set of 25 stands. The dendrogram diagram (Fig. 2) produced by the two-way indicator type analysis (TWINSPAN) recorded six clusters of plants that reflect the natural communities' composition in the field. Each cluster consists of a cluster of stands with more plant uniformity than the other clusters.

Cluster A consists of three stands located at Mastroh. This cluster is indicated by *Arthrocnemum macrostachyum* (important value = 38.3), and dominated by *Najas marina* subsp. *armata* (IV= 76.7). The most important associated species in this cluster is *Typha domingensis* (IV= 63.3) and *Phragmites australis* (IV= 61.7). Cluster B contains four stands located at Mastroh. *Juncus acutus* is the indicator species of this cluster with IV equals 28.8. This cluster is dominated by *Potamogeton pectinatus* (IV= 72.5), while the codominant species were *Najas marina* subsp. *armata* (IV= 67.5). Cluster C consists of four stands located at Mastroh. *Suaeda vera* indicates this cluster with IV of 36.3.

Cluster D involves three stands located at Al Maksabah. This cluster is indicated by the *P. pectinatus* (IV = 46.7) and dominated by *P. australis* (IV = 73.3). Cluster E comprises eight stands located mainly at Deshimi. *N. marina* subsp. *armata* is the indicator species of this cluster (IV=90.3), while *P. australis* (IV= 80.6) was the dominant species. Cluster F is composed of three stands located at Abo Amer. *P. australis* (IV = 80) represents the indicator species in this cluster.

The results given in Table (1), *T. domingensis*, *S. vera* and *A. macrostachyum* showed a very high significant difference (P< 0.001) between clusters. A relatively high significant variation (P< 0.05) is noticed for *P. pectinatus*, *J. acutus*, *Ceratophyllum demersum*, and *Limbarda crithmoides* among all clusters. Two species; *Najas marina* and *Phragmites australis* are not significantly different among clusters.

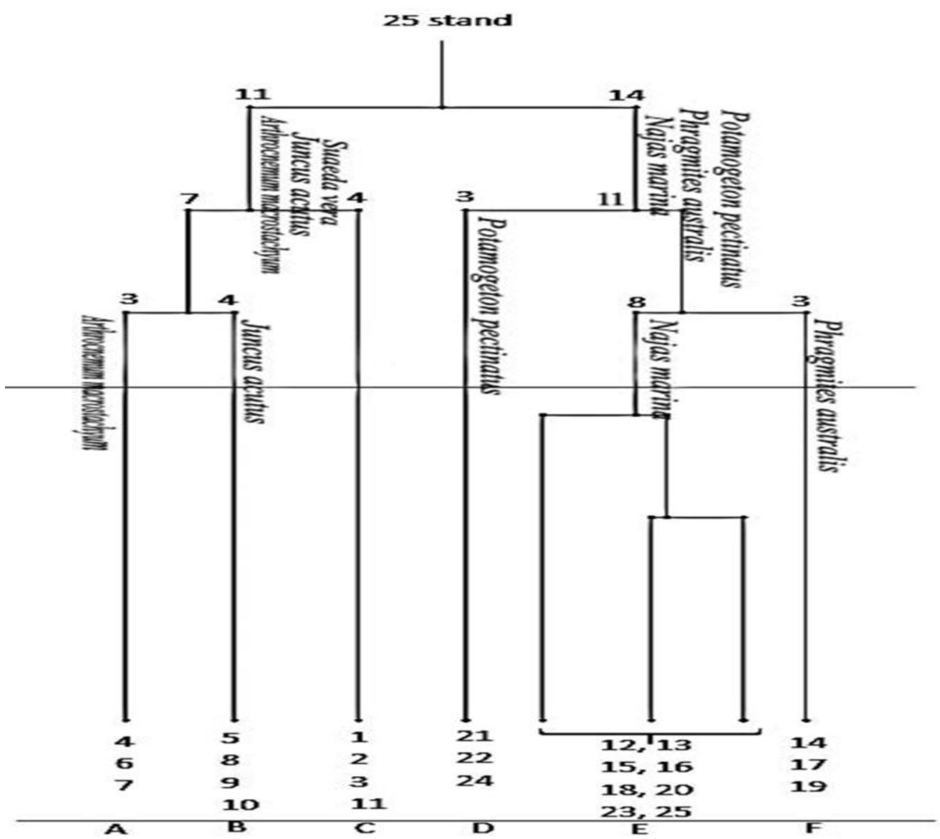

Figure (2): Two way indicator species analysis (TWINSPAN) dendrogram of 25 sampled stands. Letters A to F represented six clusters.

Table 1: Means ± SD of dominant species importance values.

Species	Clusters						P-value
	A	B	C	D	E	F	
Najas marina Najas marina* subsp. *Armata (H. Lindb.) Horn	76.7±2.4	67.5±8.3	77.2±3.5	70.3±4.1	90.3±7.4	85.7±12.5	0.067ns
Typha domingensis (Pers.) Poir.ex Steud	63.3±18.9	62.5±4.3	75.0±11.2	35.0±10.8	32.5±8.7	0.00	0.000***
***Potamogeton pectinatus* L.**	20.0±28.3	72.5±15.2	41.3±24.6	46.7±12.5	21.9±15.4	10.0±14.1	0.008**
Phragmites australis (Cav.)Trin.ex Steud	61.7±22.5	50.0±33.9	51.3±31.3	73.3±12.3	80.6±12.4	80.0±11.3	0.292ns
***Juncus acutus* L.**	36.7±4.7	28.8±34.7	0.00	0.00	0.00	0.00	0.010**
Suaeda vera Forssk. Ex. J. F. Gmel.	36.7±4.7	0.00	36.3±21.0	0.00	0.00	0.00	0.000***
***Arthrocnemum macrostachyum* (Moric.) Moris et De/Ponte**	38.3±8.5	43.8±4.2	10.00±17.3	0.00	0.00	0.00	0.000***
***Ceratophyllum demersum* L.**	0.00	17.5±17.9	0.00	6.7±9.4	26.3±13.2	50.0±21.6	0.003**
***Limbarda crithmoides* (L.) Dumort.**	0.00	0.00	0.00	16.7±12.5	1.3±3.3	0.00	0.005**

2- Species–environment relationships

The coordination diagram resulting from Canonical Correspondence (CCA) regarding the relationship between plant species, water, and the sediment is shown in Figures (3) and (4). The dots represent species, and the arrows represent environmental variables (water and sediment). The length of the arrow expressed its relative importance. Dropping perpendicular to the arrows from each of the "species points" indicates to the species' relative position along the ecological gradient represented by the arrow. The relationship of vegetation – sediment agents is presented on the ordination graph resulting from the CCA of the species biplot and environmental agents (Figure 3). *A. macrostachyum* (dominant species in cluster A), *S. vera* (indicator species of cluster C), *T. domingensis* (codominant species in cluster C), *P. pectinatus* (dominant species in cluster B) and *J. acutus* (indicator species of cluster B) showed a close positive relationship with pH, EC, TDS, HCO_3^-, Cl^-, Na^+, Ca^{++} and Mg^{++} at the upper and lower right side of CCA diagram. In the down left side of the CCA diagram, *Najas marina* (indicator species of cluster E), *Phragmites australis* (indicator species of cluster B) and *Ceratophyllum demersum* (codominant in cluster F) showed very close positive relationships with other sediment variables such as nutrients variables (N, P, K) and OC and negative relationships with salinity variables (EC, TDS, HCO_3^-, Na^+, Ca^{++}, Mg^{++}) and pH.

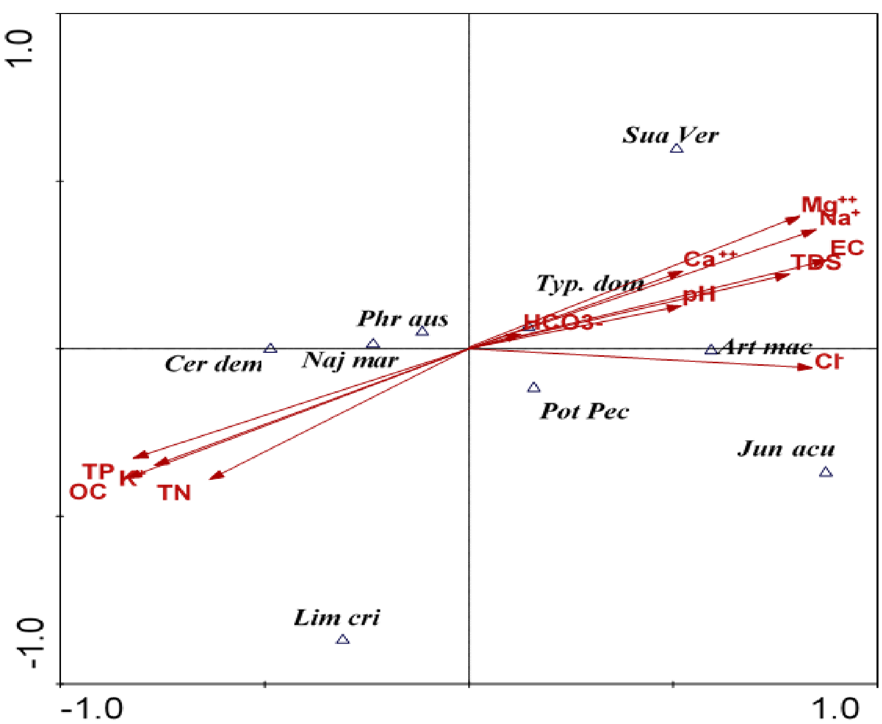

Figure (3): Canonical Correspondence Analysis (CCA) ordination diagram of plant species along the gradient of sediment variables (arrows). The indicator and preferential species are indicated by first three letters of genus and species respectively (listed in Table 1).

The relation between vegetation and water variables is indicated on the coordination diagram resulting from the CCA of the species biplot and environmental variables (Figure 4). *N. marina* and *P. australis* showed a clear positive relationship with water TP and TN values at the upper left side of the CCA plot. While *C. demersum* showed a very close relationship with pH, Mg^{++} and Ca^{++} at the lower left side of the graph. On the other hand, *S. vera*, *T. domingensis*, *P. pectinatus* and *A. macrostachyum* showed a positive correlation with EC, TDS, HCO_3^-, Cl^- and Na^+ on the upper and lower right side.

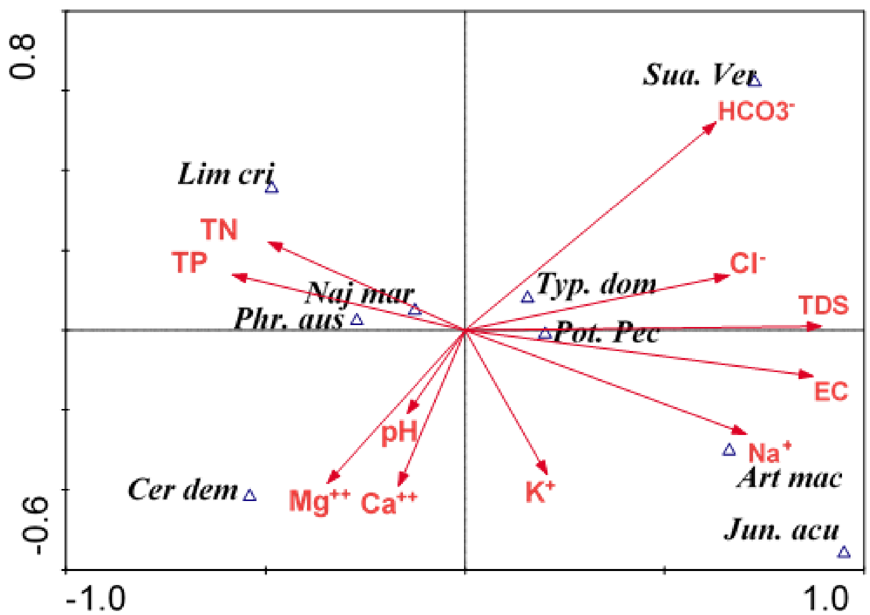

Figure (4): Canonical Correspondence Analysis (CCA) ordination diagram of plant species along the gradient of water variables (arrows). The indicator and preferential species are indicated by first three letters of genus and species respectively (listed in Table 1).

3- Sediment analysis

The obtained data in Table (2) showed the mean and One –Way analysis of soil variables of the six vegetation clusters resulted from TWINSPAN analysis in the study sites. Cluster A exhibited the highest mean values of pH, EC, TDS, Cl^-, Ca^{++} Mg^{++} and Na^+ (8.6, 10.4 mS/cm, 5.7 mg/l, 0.82 mg/100g, 0.95 mg/100g, 1.6 mg/100g and 40.3 mg/100g respectively). Clusters B and C in the same trend of cluster A where the three clusters characterized Mastroh location.

Cluster D recorded the highest mean value of HCO_3^- (0.77 mg/100g), OC (3.5 mg/100g), TN (36.6 mg/100g), TP (17.2 mg/100g), K^+ (10 mg/100g), but exhibited the lowest mean values of pH, Ca^{++} and Mg^{++} (8.2, 0.25 mg/100g and 0.57 mg/100g, respectively). Cluster F showed the lowest mean value of pH (7.7). Clusters D, E and F showed lower salinity content than clusters A, B and C, but nutrient content showed the reverse trend.

The results of ANOVA analysis revealed that there is a very high significant variation of sediment EC, TDS, Cl^-, OC, TP, K^+, Mg^{++}, and Na^+ among vegetation clusters ($p < 0.001$). TN showed significant variation ($p< 0.01$). Whereas pH, HCO_3^- and Ca^{++} showed no significant variation among vegetation clusters.

Table (2): Mean values ± SD **of sediment characteristics of vegetation clusters and ANOVA analysis of environmental variables. EC= Electrical conductivity; TDS= Total dissolved salts; CO_3= Not detected; HCO_3^-= Bicarbonate; Cl^-= Chlorides; OC= Organic carbon; K^+= Potassium; Na^+= Sodium; Ca^{++}= Calcium; Mg^{++}= Magnesium; TP= Total phosphorus and TN= Total nitrogen. * = Significant at P ≤ 0.05; ** = Significant at P ≤ 0.01 and *** = Significant at P ≤ 0.001.**

Sediment parameters		Clusters						P-value
		A	B	C	D	E	F	
pH		8.6±0.10	8.5±0.06	8.3±0.27	8.2±0.33	8.3±0.28	8.3±0.07	0.365ns
EC mS/cm		10.4±0.08	9.9±0.29	8.8±1.72	6.7±0.12	6.3±0.49	6.6±0.65	0.000***
TDS mg/l		5.7±0.45	5.4±0.30	4.5±0.76	3.7±0.17	3.5±0.34	3.7±0.48	0.000***
HCO_3^-	mg/100g	0.72±0.04	0.64±0.06	0.72±0.14	0.77±0.01	0.64±0.09	0.65±0.08	0.403ns
Cl^-	mg/100g	0.82±0.05	0.73±0.08	0.60±0.09	0.60±0.02	0.49±0.07	0.49±0.08	0.000***
OC	mg/100g	0.81±0.08	1.1±0.29	1.6±0.88	3.5±0.37	3.1±0.37	3.00±0.16	0.000***
K^+	mg/100g	8.8±0.17	8.7±0.20	8.8±0.38	10.0±0.61	9.5±0.50	9.7±0.16	0.00***
Na^+	mg/100g	64.0±0.78	63.8±0.79	57.7±8.5	39.9±0.82	42.8±2.07	44.9±0.98	0.00***
Ca^{++}	mg/100g	0.95±0.04	0.92±0.05	0.71±0.24	0.25±0.09	0.60±0.61	0.37±0.02	0.229ns
Mg^{++}	mg/100g	1.6±0.00	1.5±0.07	1.3±0.40	0.57±0.25	0.70±0.11	0.82±0.06	0.00***
TN	mg/100g	32.1±4.03	30.9±0.26	28.5±0.57	36.6±0.33	27.0±1.00	33.5±3.63	0.003**
TP	mg/100g	16.7±0.92	14.6±0.30	15.2±0.66	17.2±0.13	15.1±0.08	16.9±0.29	0.00***

4- Water analysis

It is obvious from Table (3) that the mean values of water variables between clusters produced by TWINSPAN in the study sites. The obtained data indicated that cluster A showed the highest mean values of EC, TDS, Cl^-, Na^+ (9.7 mS/cm, 5.7 mg/l, 2.6 mg/100g and 40.3 mg/100g, respectively). Cluster B exhibited the highest mean values of K^+ and Ca^{++} (3.2 mg/100g and 27.8 mg/100g, respectively). Cluster C attained the highest mean values of HCO_3^- (6.8 mg/100g). Cluster D had the highest mean values of TN and TP (3.5 mg/100g and 0.80 mg/100g, respectively). Cluster F showed the highest mean values of Mg^{++} (34.3 mg/ml).

The results of ANOVA analysis revealed that there is a very high significant variation ($p < 0.001$) of water between the clusters EC, TDS, HCO_3^- and $Na^{+,}$ while Cl^-, TN, and TP showed significant ($p < 0.01$), whereas K^+ ($p < 0.001$). pH showed no significance between vegetation clusters.

Table (3): Mean values ± SD **of water characteristics of vegetation clusters and ANOVA analysis of environmental variables. EC= Electrical conductivity; TDS= Total dissolved salts; CO_3= Not detected; HCO_3^-= Bicarbonate; Cl^-= Chlorides; K^+= Potassium; Na+= Sodium; Ca^{++}= Calcium; Mg^{++}= Magnesium; TP= Total phosphorus and TN= Total nitrogen.* = Significant at P ≤ 0.05; ** = Significant at P ≤ 0.01 and *** = Significant at P ≤ 0.001.**

Water parameters		Clusters						P-value
		A	B	C	D	E	F	
pH		8.4±0.16	8.3±0.07	8.1±0.04	8.4±0.34	8.4±0.25	8.3±0.11	0.457ns
EC mS/cm		9.7±0.33	9.7±0.21	8.4±1.21	6.4±0.26	6.4±0.29	6.6±0.46	0.000***
TDS mg/l		5.7±0.19	5.3±0.49	4.8±0.80	3.53±0.11	3.5±0.16	3.6±0.25	0.000***
HCO_3^-	**mg/100g**	6.5±0.14	6.2±0.14	6.8±0.45	5.9±0.16	5.8±0.25	5.8±0.25	0.000***
Cl^-	**mg/100g**	2.6±0.11	2.4±0.22	2.2±0.37	2.4±0.61	1.7±0.31	1.7±0.14	0.008**
K^+	**mg/100g**	2.9±0.59	3.2±0.54	2.3±0.07	2.3±0.09	2.5±0.12	2.6±0.12	0.020*
Na^+	**mg/100g**	40.3±2.65	40.3±1.48	35.7±2.49	32.5±0.52	33.2±1.06	34.3±0.94	0.000***
Ca^{++}	**mg/100g**	27.5±0.41	27.8±0.39	27.0±0.01	27.3±0.47	27.5±0.50	27.7±0.47	0.334ns
Mg^{++}	**mg/100g**	5.1±0.34	5.3±0.17	5.3±1.17	3.7±0.08	5.9±1.59	6.8±0.59	0.086ns
TN	**mg/100g**	2.6±0.03	2.7±0.07	2.7±0.14	3.5±0.08	3.0±0.37	2.9±0.20	0.004**
TP	**mg/100g**	0.22±0.02	0.23±0.01	0.26±0.05	0.80±0.11	0.52±0.26	0.49±0.19	0.005**

DISCUSSION

The distribution and abundance of aquatic plants are greatly influenced by variations in environmental agents; this is a fact for all species. The implementation of this fact contributes to the recognition of habitats and populations that are accurate measures of major environmental changes, such as measures of ecological probity **(Aznar et al., 2003; Bornette and Puijalon, 2011)**. **Lacoul and Freedman (2006)** evaluated various environmental factors that the effect of on the aquatic plants distribution in freshwater ecosystems. Thus, the chemical structure of sediment and water is an important determinant of aquatic vegetation structure and composition. Aquatic plants distribution and abundance affected by many environmental factors pH, salinity and nutrients (nitrogen and phosphate) concentration **(Magee *et al*., 1999; Lacoul and Freedman, 2006; Bornette and Puijalon, 2011)**.

Vegetation analysis of the studied sites revealed that the submerged plant *Najas marina* subsp. *armata* (H. Lindb.) Horn. was associated with nine species. The low plant diversity may be attributed to that *N. marina* is a submerged plant growing in open water and species of this habitat are highly specific to this habitat. Also, different disruption sources that this habitat subjected to them as water pollution, cleaning performs and control of aquatic weeds may interpret the decrease in the associated plants of *N. marina*, this interpretation agree with that reported by **Shaltout *et al*. (1994&2005)**.

Concerning the plants - environment (water and sediment) relationship, CCA analysis revealed that, pH, salinity (EC and TDS), nitrogen and phosphorous were the most effective environmental factors in distribution *N. marina* subsp. *armata*. Concerning *N. marina* and *P. australis*, there was a very close positive relationships with sediment and water variables such as nutrients variables (N, P, K) and OC and negative relationships with salinity. A study of various species of Najas developing in Allaqi as *N. marina* subsp. *armata*, *N. horrida* and *N. minor*) to different conditions revealed that TDS are from factors controlling species growth which agree with this study **(Yacoub, 2009)**. In addition, **Shaltout and Al-Sodany (2008)** in a study of Burullus lake vegetation revealed that the common species behavior and types of vegetative were affected by some environmental factors as anthropogenic gradients, salinity, fertility and soil moisture. Regarding *P. australis*, which featured by a broad environmental scale at different habitats, it was reported the decline in salinity values increase its growth in Lake Burullus **(Al-Sodany, 1998; Shaltout and Al-Sodany, 2008)**.

Also, our results showed that *A. macrostachyum*, *S. vera*, *T. domingensis*, *P. pectinatus* and *J. acutus* showed a close positive relationship with salinity variables (EC, TDS, HCO_3^-, Cl^-, Na^+, Ca^{++} and Mg^{++}). These data coincide with **Shaltout and Al-Sodany (2008)**, where the rise in salinity improves the halophytic growth as *A. macrostachyum*, *S. vera* and *J. acutus*. *P. pectinatus* is the highest common submerged plant in Lake Burullus, where it endures high levels of salinity, alkalinity and pH, but it isn't prefer nutrient- poor water bodies **(Kantrud, 1990)**. This plant is extremely tolerant to eutrophic waters, and may be the only submerged macrophyte that grows well in these polluted waters. Where, *P. pectinatus* can remediate metals and accumulate them in its leaves and stems at polluted sites **(Demirezen and Aksoy, 2004)**.

Clusters A, B, C followed by cluster D and F which characterized the northern section attained the highest mean values of salinity and nutrient variables and lowest nutrients variables, but cluster D showed the reverse trend. This results confirmed by that obtained by **Eid *et al*. (2020)**, where they reported that southern locations attained higher concentrations of nutrient than those of the northern locations which also, decided by **El-Zeiny and El-Kafrawy (2017) and Elsayed *et al.* (2019)**. This may attributed to that Lake Burullus was subjected to agricultural, industrial and domestic effluents resulted from anthropogenic activities **(Shaltout and Khalil 2005; Eid *et al*., 2010)**.

CONCLUSION

In conclusion, the *N. marina* plant affected greatly by salinity where its distribution decrease with increase salinity amount. The plant distribution was at the north western section of Lake Burullus and south section at the low salinity locations. Generally the reciprocal relationship of plants – environment is embedded in all living systems, which are the fundamental basis for the various types of sustainable improvement, especially the essential basis for water sustainable development. Community features of aquatic plant are essential indicators for water quality. In addition, this study will help in planning for plant manage and conservation. The habitat salinity-nutrient index had the highest influence on species configuration.

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