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Contribution to the Eco-Palynological Studies of Wadi El Natron, Egypt

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Abstract

Palynological study of three soil profiles has been carried out from the Wadi El-Natrun area, Western Desert of Egypt for their pollen content dating Late Pliocene to present. Results revealed predominance of Mangroves vegetation *Avicennia marina* during Late Pliocene, and, Early Pleistocene. A warm humid climate with intermittent dry periods is indicated from the Late Pliocene recorded fossils. Fossil remains of *Juncus* and *Salsola* pollen types. *Lycopodium* spores, *Pinus* and *Concentricystes* spores were recorded during Late Pliocene and Holocene, Early Pleistocene which suggest a humid and warm climate at this period. The climate was warm arid alternating with warm humid and sometimes cool-temperate rainy periods as indicated by the presence of grasess (Poaceae) and (conifer, *Pinus*). Swamp elements, *Typha* and *phragmites* pollen types were recorded with high percentage indicating a swampy habitat during Holocene period. The present vegetation cover of the studied area represented by 27 species belonging to 12 families, 4 annuals and 23 perennial plants and a few individuals of *Acacia*, *Tamarix type* the most dominant shrubs, followed by associate types e.g halophytes *Salsola*, *Zygophyllum, Cornulaca* and few of annuals *Senecio* and *Sonchus* which represent mesophytic species, while the differences in vegetation of present and old may due to the environmental and climatic changes. In the present, the rising salinity and high nutrient loading due to human activities has allowed for the growth of the halophytic community. So, Palynological investigations may be used to detect the effects of climatic changes on terrestrial plant vegetation and as additional tool to predict the past climatic changes.

Keywords: Wadi El Natrun; Palynology; Climatic Changes; Palaeovegetation; Pliocene; Palaeoenvironment

Introduction

Wadi El-Natroun is a narrow depression located in the west of the Nile Delta, approximately 110 km northwest of Cairo between longitudes, 30º 02´ and 30º 29´ E and latitudes, 30º 16´ and 30º 32´ N (Figure 1). The total area of Wadi El Natrun is 281.7 Km2, extended in a NW-SE direction and 23 m below sea level. The underground water origin is seepage from the Nile stream, due to its proximity and low level [1]. Wadi El Natrun area considered as an extremely arid region where the mean annual rainfall, evaporation and temperature are 41.4 mm, 114.3 mm and 21ºC respectively [2]. The saline lands are widely distributed globally and constitute about 10% of the Earth's terrestrial surface OLeary and Glenn, Zahran [3,4] reported that the inland salt marshes of the Egypt's Western Desert are found in the form of Sabkhas around the lakes, springs and wells of the oases, e.g, Wadi El-Natrun, and El-Faiyum. Flora of Egypt comprises 2.085 species, 130 families and 722 genera of which 1.095 species grow in the Mediterranean region [5]. According to

Appelgren [6] vegetation has been widely used to describe habitat characteristics [7]. Kassas Stated that, in Egypt, desert vegetation is the most important and characteristic type of natural plant life, also Abd El Ghani, et al. [8] stated that vegetation covers vast area and formed mainly of xerophytic shrubs and sub-shrubs. Palynology is the study of pollen grains produced by seed plants (angiosperms and gymnosperms) and spores produced by pteridophytes, bryophytes, algae and fungi [9]. Palynology serves as a tool for reconstruction of past vegetation and environment. It can also be applied to taxonomy, genetics, evolutionary studies, honey studies, forensic sciences, and allergy studies, tracing vegetation history in individual species and in communities, climate change studies and study of past human impact on vegetation [10]. Pollen analyses provided information on the regional and local vegetation history [11]. One of the aims of palynological studies is the recognition of vegetation and plant communities on the basis of associated pollen grains.

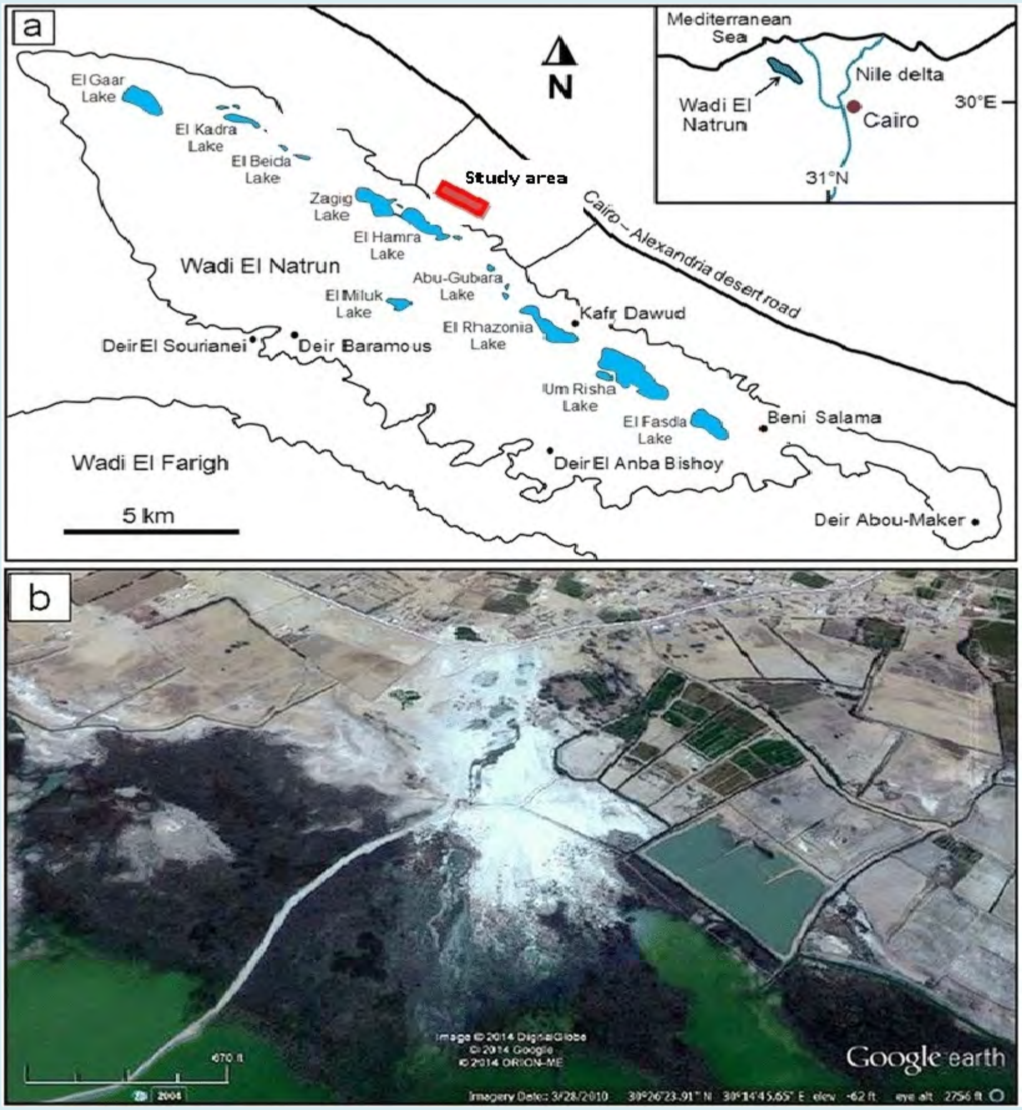

Figure 1: Satallite Map Showing Location of the Study Area.

Climate change is often invoked as a trigger for the collapse of civilizations. The fall of the Akkadian Empire and the end of the Egyptian Old Kingdom around 4,200 years BP have both been attributed to climatic change resulting in regional desiccation [12,13]. Dating of archaeological sites, lake sediments and faunal remains indicates that wet conditions were established in the Sahara by around 10,000 BP after a long period of aridity associated with the last glacial period [14,15]. The main objective of this investigation was to study Wadi El Natrun in the western desert sector of Egypt through surveying present vegetation cover of Wadi El Natrun area and by comparing between present and old vegetation of Wadi El Natrunarea, reconstructing past vegetation covers and the response of dry and wet ecosystems to changes in regional climate based on palynological investigation of fossil pollen data.

Study Area

Geology and Geomorphology

Wadi El Natrun is one of the three sub-basins that compose the large circular depression of Western Desert. Wadi EL-Natrun area is one of the promising areas in the Western Desert for reclamation and utilization due to its location and the presence of ground water in a suitable quality for irrigation. It is located in the northeast corner of the Western Desert between longitudes 30° 00 and 30° 30 East, and latitudes 30° 15′ and 30° 30′ North (Figure 1). Wadi El Natrun Depression has an oval shaped, with about 50 km in length and the width ranges from 15 to 20 km. The total area of the depression that lies below sea level (0-23 m BSL) is about 50000 hectares and the climate hot deserts.

Geology of Wadi EL-Natrun

Geology of Wadi El-Natrun was studied by many authors e.g. (Beadnell, Said, and Hendriks, et al.) [16-18]. In Wadi EL-Natrun depression, the surface is underlain by both Tertiary and Quaternary sediments with local outcrops of basalt and diorite (Figure 2). These rocks display different litho faces (sand, gravel condition). The surface sandstone and clay limestone etc belonging to different geological environments are rather simple while the subsurface structures are very complicated.

Figure 2: Phragmites community in red water dominated with *Phragmites austoralis*

El Hamra Lake

El-Hamra Lake, Wadi El-Natrun depression, Beheira, Egypt, Quaternary, Cenozoic sedimentary rocks, Age: Pleistocene (0-2.588 Ma), Lithology: Sandstone-siltstone. Hamra Lake connected by a small canal in the northwestern end of Zug Lake (Figure 1).

Pliocene

Wadi EL-Natrun area, the Pliocene dominated by shallow marine and brackish water deposits which overlain by Nilotic sands and gravel (Pleistocene) and underlain by a thick sandy section belonging to unconformable to lower Miocene Moghar Formation [19] .

Wadi EL Natrun Formation

The effect of late Pliocene pluvial in southern Egypt was the convert of the Nile Valley gulf into a channel of a master stream; Paleo-Nile [20] and also reported that Wadi EI-Natrun depression was subjected to considerable lowering during the early Pleistocene arid climate. Sediments are largely restricted to the depression area developed into gypseous clays and sands of typical brackish water origin. The portion of Pliocene was distinct into two series, i.e., an upper (El Mulok) dominated with halophytic vegetation and a lower series (Beni Salama) halophytic and mesophytic vegetation.

Salt Lakes and Sabkhas

Wadi El Natrun depression is occupied by a series of salt-water lakes, which are the lowest elevation in the depression and is usually occupied by saline water (Figure 2). Most important lakes are from northwest to southeast; El-Gaar, Khadra, El-Beida, El-Saad, El-Hamra, Gabboura, El-Rasoneya. The saline lakes receive saline water from the underlying groundwater through the faults and joints. The level of water in these lakes is fluctuated seasonally, becoming higher in the autumn and the winter and lower in the spring and the summer. This is much related to the general fluctuation of the groundwater table and the variation of the evaporation rate. The saline waters in these lakes are rich in Natrun and halite salts. The salt marches occupy the area between and around the salt lakes. The surface of these marches is covered with sabkha consisting of crystalline gypsum, sand and clay with some calcareous materials [21].

Materials and Methods

The present vegetation analysis was carried out on six community types representing the vegetation of the study area at El Hamra site. In each community, 5 stands (20m x 20m)^2 were studied for each community type. Determining the dominant plants and visual estimate (using stand method for plants counting to determine the dominants and associates species according to references methods listed in this paper) of the total cover and the individual cover of each species percentage dominance and abundance scale following Braun [22]. Each stand group representing a habitat type, the dominant species, community associates, number of individuals, abundance percentage were recorded and calculated according to Misra [23]. The vegetation analysis, floristic composition were carried out according to Hanson, et al. and Kershaw [24,25]. Within each stand, plant species were recorded. Taxonomic nomenclature followed Tackholm [5], updated with Boulus [26,27]. Plant cover was estimated quantitatively by the line intercept method (Canfield 1941), Indices of halophytism (IH) and xerophytism (IX) are obtained according to the equations:

$$IH = \frac{H \times 100}{T}, IX = \frac{H \times 100}{T}$$

$$\textbf{Abundance: ab } \% = \frac{No.\ individuals\ of\ a\ given\ species\ X\ 100}{Total\ No.\ of\ all\ individuals}$$

Soil samples representing each community type were collected from exposed surfaces of 20 cm, deep profiles. The samples were air-dried and mixed. The soil characteristics were determined using the methods described by Pansu, et al. and Margesin, et al. [28,29].

Sample Collection for Pollen Analysis

Three soil cores were done to 15 m depth in different localities at study area (Figure 3). 5gm soil was sampled every 125 cm of each soil core for pollen analysis. Samples were macerated following the technique of Erdtman [30]. Soil samples were treated with 10% KOH solution to deflocculate the matrix then washed several times with water after which it was passed through a sieve. The filtrate was transferred in polythene jars and treated with 40% HF for at least 6-7 days to dissolve silica. After decanting the HF, the material was then washed with water several times until the sample was free of Acid and then the residue was acetolysed by standard acetolysis method using acetolysis mixture (9:1, acetic anhydride and conc. sulphuric acid). The processed samples for microscopic observation were stored in 50% Glycerine with few phenol drops to avoid microbial contamination. A *Lycopodium* tracer was added to calculate pollen concentration (grains/cm. Pollen analysis, identification routinely used x400 magnification with x1000 magnification for small and difficult types with reference to standard keys [31,32] and the reference collection key pollen of Environmental Studies and Research Institute Minufiya University (ESRI). Pollen identified to the lowest taxonomic level possible with reference collections, atlases e.g, Moore [33], and other publications [34]. Pollen grains that were broken, corroded, hidden or otherwise damaged were counted as 'Indeterminate', and those that were unidentifiable were counted as 'Unknown.

Figure 3: Locations of the studied profiles at Wadi el Natrun West Nile Delta**.**

Chronology and Dating

Radiocarbon datings obtained through correlation with the sedimentary layers on the basis of archaeological findings regarding such other archaeological antiquities considered markers of age. Chronology of soil strata was obtained by Austrian Mission for archaeological excavations in Egypt.

Pollen Analysis

Pollen samples were prepared using 10% Na-pyrophosphate, sieving using 200–300 μm and 7 μm meshes, 10% HCl, acetolysis, heavy liquid separation (Na meta tungstate hydrate with specific gravity of 2.0 and centrifugation at 2000 rpm for 20 minutes), 40% HF, and mounting with glycerol jelly on permanent slides according to Faegri, et al. [35]. *While Lycopodium* spores were used to calculate pollen concentration (pollen grains per / gram = p/g), and pollen analyses were performed at 400× and 1000× with immersion oil light microscopy for determinations. The pollen terminology followed Hesse, et al. [36]. Photomicrographs of fossil pollen were taken, difficult to identify pollen were sent to Professor Sekena Ayyad, Botanical Institute of the Bergen University Norway, for identification.

Results

Current Climate of the Study Area

Climatic factors/ Months	Rainfall (mm)	Temperature(C°)	Relative humidity (%)	Evaporation (mm/ day)	Wind velocity (km/hr)
January	10	16	57	2.7	10
February	8.1	18	55	2.9	10.5
March	4.1	25	45	3.4	11.8
April	1	29	48.2	4.4	12
May	0	33.5	50	5.1	10.1
June	0	36	52	5.5	10.5
July	0	37	56	4.8	10.3
August	0	38	57	4.7	8.7
September	0	33	58	4.2	8.5
October	1.2	27.5	58.2	4	8.9
November	2.1	25	56.1	3.3	9.6
December	9.3	22	55	2.8	10.1

Table 1: Mean Values of Climate of Wadi El Natrun (from 2014-2019).

Meteorological data recorded at local weather stations for the period (2014-2019) showed annual mean rainfall of 10 mm January to no rainfall in May to September, annual mean temperature of varied from 38.0°C in August to 16.0°C in January, while annual mean relative humidity ranging from 58.2% in October to 45% in March. Evaporation annual mean varied from 5.5 mm/day June to 2.7mm/day January. Wind velocity annual mean varied from12 km/h in April to 8.5 km/h in September (Table 1).

Physical and Chemical Analysis of Soil Profiles

	Plant Communities					
Soil characters (%)	Cornulaca monocantha	Cyperus lavegatus	Phragmites austoralis	Desmostachya bipinnata	Salsola impricata	Tamarix aphylla
Gravel (>2.057 mm)	0.32±0.03	0.54±0.09	0.22±0.03	0.27±0.05	0.06±0.06	0.04±0.00
Coarse sand (2.057-1.003 mm)	6.73±3.81	11.41±3.35	6.09±2.47	6.15±0.09	6.36±1.45	5.60±1.44
Median sand (1.003-0.500 mm)	11.38±3.41	10.26±2.45	5.88±2.40	4.46±1.23	5.10±1.85	5.55±1.13
Fine sand (0.500-0.211 mm)	33.61±7.12	23.90±3.36	35.35±6.89	34.05±3.53	30.69±4.04	27.17±3.95
Very fine sand (0.211-0.104 mm)	31.74±4.94	36.10±9.80	32.22±5.94	40.10±4.40	37.41±5.57	35.50±1.28
Silt (0.104-0.053 mm)	10.30±3.20	8.94±4.45	13.74±5.83	14.52±1.56	13.65±2.57	14.60±2.29
Clay (<0.053 mm)	3.23±1.98	3.56±1.31	5.91±1.65	4.53±0.94	4.31±0.71	5.25±1.19
Moisture content	5.70±2.20	8.10±0.51	6.30±0.10	6.60±0.80	3.30±0.30	3.50±0.30
Porosity	35.80±5.20	44.60±5.40	40.50±3.50	42.40±3.50	40.90±3.70	40.50±3.90
WHC	36.90±2.20	43.50±3.70	42.50±2.00	41.60±7.50	37.10±5.00	38.70±4.50
Organic carbon	0.60±0.40	1.50±0.30	0.70±0.30	0.30±0.10	0.70±0.10	0.80±0.10
$CaCO_3$	6.70±2.20	10.50±3.50	11.50±4.60	7.50±1.80	8.50±1.20	7.20±1.50
TSS	2.50±0.80	1.50±0.40	2.50±0.30	2.80±0.20	2.40±0.10	2.60±0.10
Chlorides (ClG)	0.09±0.03	0.11±0.08	0.10±0.03	0.06±0.01	0.02±0.01	0.31±0.02

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Sulphate (SO_4!)	0.21±0.01	0.41±0.05	0.25±0.05	0.17±0.09	0.11±0.03	0.28±0.06
Carbonates (CO_3G)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Bicarbonates (HCO_3G)	0.09±0.04	0.10±0.05	0.11±0.04	0.03±0.01	0.14±0.05	0.14±0.04
pH	8.30±0.30	8.20±0.50	8.00±0.50	7.80±0.10	7.70±0.30	8.50±0.30

Table 2: Mean values of physical and chemical characters of soil samples of the various community types.

Soil Analysis of Present Vegetation Cover

Cyperus Lavegatus: Data in Table 2 showed clearly that, the mechanical analysis of the soil samples adjusting this community types revealed the highest percentage of soil particles was very fine sand (mean 31.74±4.94). The percentage of silt was high mean value (10.30±3.20%). The soil moisture content was generally low with mean value of (5.70±2.20%). The total soluble salt content was low and attained mean value of (2.5±0.80%).

Phragmites Austoralis: The very fine sand (class 0.211-0.104 mm) recorded mean value (36.10±9.80%). The soil moisture content was relatively high (mean 8.10±0.51%). The soil pore-spaces attained high value (mean 44.60±5.40%). The soil salinity was moderate with mean value (1.50±0.40%).

Desmostachya Bipinnata: Table 2 shows the soil of *Desmostachya bipinnata* is mainly sandy with predominance of fine sand value mean (35.35±6.89%). The silt and clay particles are poorly represented. The soil moisture shows a wide range of variation and attained mean value of (6.30±0.10%). The soil pore-species reached mean value of (40.50±3.50%), while total soluble salt content mean value (2.50±0.30%).

Salsola Impricata: Data in Table 2 showed clearly that, the mechanical analysis of the soil samples adjusting this community types revealed the highest percentage of soil particles was very fine sand (40.10±4.40%). The percentage of silt was high (14.52±1.56%). The soil moisture content was generally low with mean value of (6.60±0.80%). The total soluble salt content was low and attained mean value of (2.80±0.20%).

Tamarix Aphylla: The very fine sand recorded mean value (37.41±5.57%). The soil moisture content was relatively high (mean 3.30±0.30%). The soil pore-spaces attained high value (mean 40.90±3.70%). The soil salinity was moderate with mean value (2.40±0.10%).

Cornulaca Monocantha: Data in Table 2 showed clearly that, the mechanical analysis of the soil samples adjusting this community types revealed high percentage of soil particles was very fine sand (35.50±1.28%). The percentage of silt was high (14.60±2.29%). The soil moisture content was generally low with mean value of (3.50±0.30%). The total soluble salt content was low and attained mean value of (2.60±0.10%).

Present Vegetation Cover

Data in Table 3 showed clearly that, Six community types were recorded; twenty-seven species (4 annuals and 23 perennials) belonging to 12 families were recorded in the study area. The most represented families are *Poaceae* 44.59%, *Chenopodiaceae* 38%, *Juncaceae* 37% and *Typhaceae* 37%. More than half of the species were perennials herbs (85.18%) and 14.81% were annual grasses.

Dominant species / Community	Associates	Family	Number Individuals	Abundance %
Cyperus laevigatus	*Juncus rigidus*	Juncaceae	37	37
	Juncus acutus	Juncaceae	22	22
	Phragmites austoralis	Poaceae	25	25
	Typha domingensis	Typhaceae	16	16
Phragmites austoralis	*Juncus rigidus*	Juncaceae	8	17.77
	Juncus acutus	Juncaceae	5	11.11
	Typha elephantina	Typhaceae	17	37.77
	Cyperus laevigatus	Cyperaceae	9	20
	Suaeda aegyptiaca	Chenopodiaceae	6	13.33

Desmostachya bipinnata	*Imperata cylindrical*	Poaceae	35	36.45
	Spergularia marina	Caryophyllaceae	31	32.29
	Stipagrostis ciliate	Poaceae	25	26.04
	Pheonix dactylifera	Palmae	5	5.2
Salsola impricata subsp. Gaetula	*Cynodon dactylon*	Poaceae	33	44.59
	Haloxylon salicornicum	Chenopodiaceae	9	12.16
	Launaea nudicaulis	Asteraceae	12	16.21
	Arthrocnemum macrostachyum	Chenopodiaceae	6	8.1
Tamarix aphylla	*Polypogon monospliensis*	Polygonaceae	13	30.95
	Sonchus maritimus	Asteraceae	12	28.57
	Hyoscyamus muticus	Solanaceae	10	23.8
	Pluchea dioscoridis	Asteraceae	5	11.9
	Acacia radiana	Fabaceae	2	4.76
Cornulaca monocantha	*Zygophyllum simplex*	Zygophyllaceae	15	30.09
	Sporopolus spicatus	Poaceae	13	29.54
	Panicum turgidum	Poaceae	9	20.45
	Senecio glaucus	Asteraceae	7	15.9

Table 3: Synthetic Characters of Present Vegetation Cover at Wadi El Natrun Study Area.

Palynological Analysis

Data obtained from (Table 4 & Figure 4), showed high representation for Concentricystes spores (15% Holocene and11% recent) at depth 875-1000 cm and 750-875cm. Lycopodium spores, recorded 56% Early Pleistocene about 15200±1600 BP and 11% Late Pleistocene about 27.400± 600 BP at depth 1000-1125 and 1250-1375cm. Pollen spectra are characterized by high percentage values of Pinus 25 % Early Pleistocene about 15200±1600 BP and 19% Late Pleistocene 27.400± 600 BP at depth 1000-1125 and 1250-1375cm. *Typha* pollen type recorded 8.9%Early Pleistocene 15200±1600 BP and 0.9% recent at depths 1125-1250cm and 0-125cm surface layer. Juncus recorded high representation 12.6% recent at depth 0-125cm surface layer and 12% Late Pleistocene about 27.400± 600 BP at depth 1250-1375cm. Poaceae wild grasses recorded 43% Late Pliocene about 27.400± 600 BP at depth 1250-1375 cm and 24.6% recent at depth 0-125cm. Cyperaceae high representation 14.8% Early Pleistocene about 15200±1600 BP at depth 1000-1125cm and 1% recent at depth 0-125cm, while Chenopodiaceae recorded high representation 51% recent at 0-125cm surface layer and 3.4% Early Pleistocene 15200±1600 BP at depth 1000-1125 cm. Finally, Avicenniaceae pollen type recorded 13% Late Pliocene 27.400± 600 BP at depth1250-1375cm and not recorded at the recent layer of the studied core.

Chronology	Depth /cm	Pteridophyt		Gym	Monocot				Dic	
		Con%	Lyco%	Pin%	TY%	JU%	PO%	CY%	CH%	Avi%
Recent	0-125	-	-		0.9	12.6	24.6	1	51.2	-
	125-250	-	-	-	0.4	-	25	2	49.8	-
	250-375	-	-	-	3.4	2	16.8	4	36.9	-
	375-500	-	-	-	-	-	16.3	4.7	40.5	-
	500-625	-	0.9	-	-	-	7.3	-	-	-
	625-750	6					9.6	5	-	-
	750-875	11	-	-	-	-	3.6	7.1	20	-
Holocene 7910±830 BP	875-1000	15	-	-	-	-	24	-	5	2

Early Pleistocene 15200±1600 BP	1000-1125	2	56	25	7	10.2	32	14.8	3.4	8
	1125-1250	-	10.4	20	8.9	7.6	37.2	10.5	5.2	11
Late Pliocene 27.400± 600 BP	1250--1375	-	11	19	3.1	12	43	-	16.5	13
	1375-1500	-	5	-	0.9	8	39.7	-	12.3	9

Table 4: Relative abundance of different pollen and spore types in five grams soil at different depths of Wadi El Natrun profile. Con=Concentricystes; Lyc= Lycopodium; Gym = Gymnospermae; Pin = Pinus; Mon = Monocotyledonae ; TY= Typhaceae; JU= Juncaceae; PO = Poaceae (Graminae); CY= Cyperaceae; Dic = Dicotolydonae; CH = Chenopodiaceae; Avi = Avicenniaceae

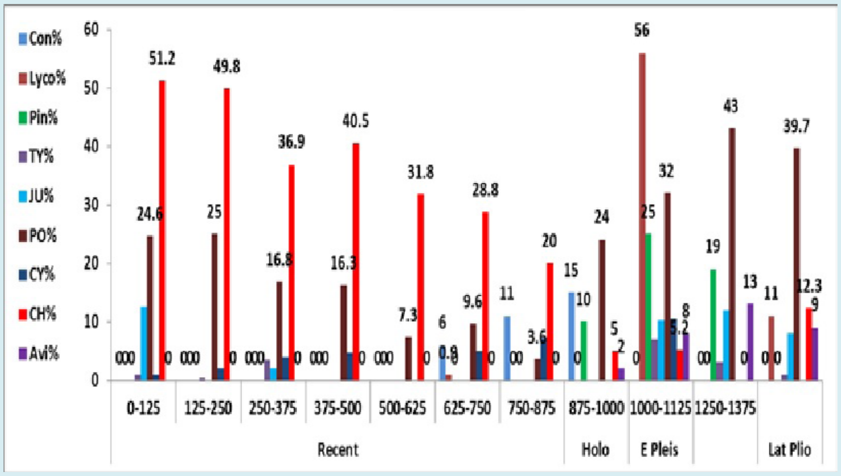

Figure 4: Pollen diagram showing relative abundance of pollen grains extracted from soil profile at Wadi El Natrun.
Pollen diagram showing relative abundance of pollen grains extracted from soil profile at Wadi El Natrun. Holo=Holocene; E Pleis= Early Pleistocene; Lat plio= Late Pliocene); Con = Concentricystes; Lyc= Lycopodium; Pin = Pinus; TY= Typhaceae; JU= Juncaceae; PO = Poaceae Graminae; CY= Cyperaceae; CH = Chenopodiaceae; Avi = Avicenniaceae.

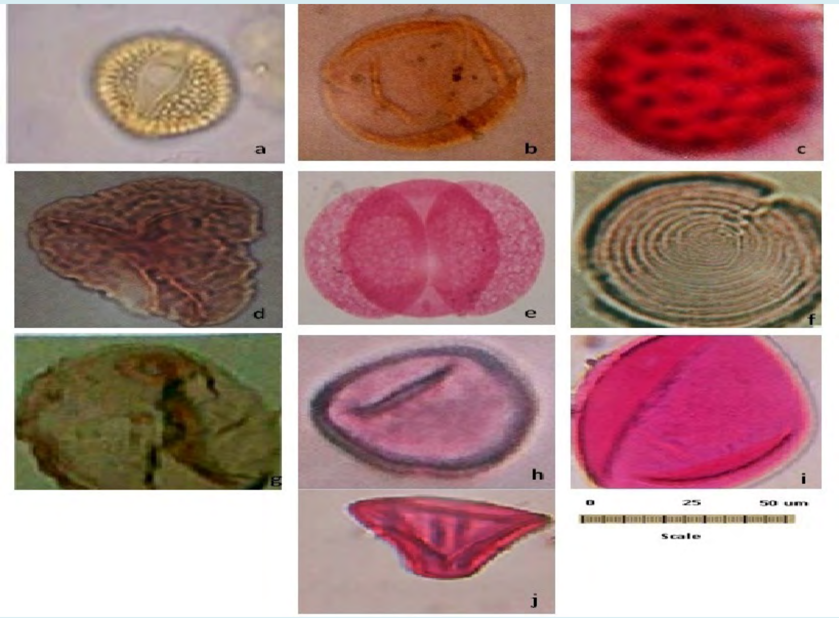

Figure 5: Representative photomicrographs (x =1000 magnification power) of pollen spores.
(a) *Avicennia* type 45um, (b) *Juncus* type 32 um, (c) *Salsola* type 45um, (d) *Lycopodium* spore 50 um, (e) *Pinus* type 50 um, (f) Concentricystes spore 42um, (g) wild grasses 28, (h) *Typha* type 39um, (i) *Phragmites* type 36um, (j) Cyperus type 24 um.

Pollen Description

- ***Avicennia* Pollen Type:** Circular, prolate, aperture tricolpate, reticulate sculpture, size 21um.
- ***Juncus* Pollen Type:** Spheroidal shape, radially symmetrical, inaperturate, size 29 um.
- ***Salsola* Pollen Type:** Spheroidal, polypantoporate, perforate sculpture, 40-45 pores, grain size (38 um). ***Lycopodium* Spore**: Sexine, reticulate sculpture, trilete spore, size 49um.
- ***Pinus:*** The grain is known as saccate, sacs similar in size the grain size, 45um, slightly granulate. ***Concentricystes***, Bilaterally symmetrical with fingerprint like concentric, spiral striations on opposite faces, 20-30 µm
- **Wild Grasses**: Monoporate, spheroid ovoid shape, porus circular, psilate granulate sculpture, grain size 28 um.
- ***Typha* Pollen**: Spheroidal, monoporate, micro-reticulate, heterobrochate sculpture, grain size 28 um.
- ***Phragmites* Pollen Type:** Monoporate, spheroid shape, porus circular, psilate granulate sculpture, grain size 36 um
- ***Cyperus Pollen***: Pear like shape, inaperturate, tectate-perforate and psilate sculpture, grain size 24 um.

Discussion

One of the aims of Palynological studies is the reconstruction of palaeoenvironmental changes. From the pollen diagram, information can be obtained about vegetation, floristic composition, climatic changes, lake sedimentation, wind direction, turnover rate of the lake ecosystem and sea levels too West[37]. A study pollen grains and spores, is one important area of research, though we can obtain important information about past plant vegetation, past climate change as well as reconstruct past environment in a given site and geological time.

The Present Climate

The studied climate (from 2014-2019) has an arid climate, with low and very variable rainfall in winter, a long dry summer, high rates of evaporation, and low humidity. The main wind direction is from the northwest but the El-Khamasin wind (April-May) from the southeast is quite strong and lasts for several days, with considerable effects on precipitation and sand remobilization particularly in the south-western sector.

Present Vegetation

Plant communities: Vegetation of the surveyed area is organized into units (6 communities). Each of these units is associated with a certain habitat type. *Cyperus laevigatus* community type: The species assemblage of this community is mixed as it includes both glycophytes and halophytes. This reflects the heterogeneity of the habitat conditions of the plant community and the wide range of ecological amplitude of the dominant species. Teyeb et al. [38] stated that several species of *Cyperus laevigatus* normally synthesize numerous metabolites in order to adapt to drought stress. *Salsola impericata* was the common ephemeral. [39].

Soil in Relation to Plant Communities

Salinity is the most important edaphic factor which affecting distribution and structure of the plant communities, moisture content and fine fractions moreover calcium carbonates also effective [40,41]. The *Cyperus laevegatus* community showed considerable dominant with associated plant species be related to the variation of soil, where soil particles are mainly of very fine sand (mean31.74±4.94%) silt fraction 10.30±3.20%, and mean value percentage of clay is (3.23±1.98%). The mean value of moisture content was 3.4±2.2%. Soil salinity is low (Table 2). Halwagy, et al. reported that the land form of affects the redistribution of rain- water and sediments as secondary effect.

Phragmites austoralis community have high contents of moisture, salinity and silt, where accumulation of deep silt, organic matter, higher contents of moisture and minerals, but low alkalinity prevail [42]. Soil salinity, organic matter, moisture content and fine material were higher in the *Juncus, Salsola, Cornulaca Phragmites and Tamarix* communities than in any of the other communities. The floristic composition showed dominance of *Poaceae,* and *Chenopodiaceae* these families represent the most common in North Africa flora [43].

Palynological Studies

The aim of this palynological study is the recognition of vegetation and plant communities on the bases of associated pollen grains. Data obtained (Table 4, Figures 4 & 5) revealed that, *Concentricystes* spores (Figure 5f) recorded with relative abundance 15% at Holocene period about 7910±830 BP, may suggest that a freshwater body and humid climate was present near the site of the study area, because these type of spores occurs in freshwater and humidity indicators according to Wang, et al. [44] *Concentricystes* assemblages reflects evergreen Quercus-dominated vegetation, and are indicative of a warm, humid climate in which freshwater lakes or alluvial flats with back-swamps prevailed. While, this findings may support African Humid Period (AHP) is a climate period in Africa during the Holocene during which northern Africa was wetter than today moreover replacement of much of the Sahara desert by grasses, trees and lakes. Later in the 20th century, conclusive evidence of a past greener Sahara, the existence of lakes [45,46] and it was recognized that the Holocene featured a humid period in the Sahara, [47]. Holocene sediments in the Mudanjiang area of Heilongjiang;

Early Pleistocene deposits in Jilin [58]; *Lycopodium* spores (Figure 5d) has been dominant during Early Pleistocene 15200±1600 BP with relative abundance 56% (Table 4 & Figure 4), in this connection [48,49] these spores indicate a humid conditions at this period, also recorded in Holocecne Nile Slits from the Nile Delta, [50]. *Pinus* pollen type (Figure 5e) recorded the highest representation 25% during Early Pleistocene 15200±1600 BP and this may indicates warm climate, Hong B [51] stated that the de-glaciation due to a climate warming stage with *Pinus* percentage increased, *Artemisia* pollen type percentage decreased and the rapid sea level rise. The pollen analysis indicates that there was a well-established forest around the lake as seen in the high fossil pollen values of *Pinus* and *Avicennia* (Figure 5a) 25, 11% during warm period of Early Pleistocene. However, there was a period of relatively low pollen of forest trees representation during Late Pleistocene 27.400± 600 BP, the obvious explanation is a reduction in pollen production caused by a decrease in the flora density of around Wadi El Natrun Lake in response to environmental stress. Cat tail dominated (*Typha* pollen type Figure 5h) *Typhaceae* 8.9% Early Pleistocene 15200±1600 BP, these plants are well known reed swamps which indicates a swampy habitat, according to Ritchie JC and Ayyad SM [52,53]. The *Juncus* pollen type (Figure 5b) recorded highest representation 12 % during Late Pleistocene about 27.400± 600 BP; these plants are well known as a salt loving or halophytic taxon which suggests an arid environment. In this connection, El Shenbary [54] mentioned that *Juncaceae* and *Chenopodiaceae* were salt marsh plants. However, Hydrophytes and rushes (*Juncus*) suggest the presence of permanent water and marshy habitats [55,56]. *Poaceae* wild grasses (Figure 5g) recorded the highest representation 43%, dating Late Pleistocene 27.400± 600 BP mostly were grasses, which indicates an open, low-diversity savanna with grasses and sedges. Salsola pollen type (Figure 5c) belonging to the family Chenopodiaceae xerophytes including salt bushes are significant, indicating that sandy habitats were also present. *Cyperus* pollen (Figure 5j) reflects significant degree of herbaceous vegetation on the valley floor, and therefore should be included in the pollen sum is best supported, in this connection Ayyad [53] stated that Cyperaceae species were growing in wet or dry places, it is salty or unsalty. There is an increasing in Poaceae and Chenopodiaceae taxa including alophylous shrubs, largely spread in salt-rich soils. Chenopodiaceae pollen type was common and associated with the Poaceae and Cyperaceae. Pollen grains which are blown into lakes can accumulated in the sediments and provide a record of past vegetation Prach [57] Stated that, different types of pollen in lake the sediments reflect the vegetation type that present around this lake, and therefore the climate conditions favorable for that vegetation. So we can conclude that the vegetation indicated by pollen assemblage found in this lower zone of the studied cores is not consistent with the present vegetation found in Wadi El Natrun studied area [58,59].

Conclusion

We can conclude that, there is a succession climatic changes leads to vegetation successions during the four studied periods, the ecosystems respond sensitively to changes in plant available moisture (precipitation) where the wet habitats forest vegetation and Mangrove were dominant during (Late Pliocene about 27.400±600 BP), followed reed swamps during (Early Pleistocene about 15200±1600 BP). The habitats changed to herbaceous vegetation during period (Late Pliocene About 27.400± 600 BP), while dominance of open vegetation then decrease in humidity, strongly suggesting decrease in precipitation late Pleiostocene. *Chenopodiaceae* recorded highest abundances 51.2% recent layer indication to habitat changing to halophytic vegetation, and then changed to mesophytic recent time.

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