Diversity and Ecological Succession Around Gaber-Oun Hypersaline Lake Ecosystem-Libya

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Diversity and Ecological Succession Around Gaber-Oun Hypersaline Lake Ecosystem - *Libya*

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***Abstract*—** This study was conducted to evaluate the ecosystem diversity and succession around Gaber-Oun Lake - Libya. The Lake is an inland at halassohaline water body located in the Sahara, south of Libya. The lake has an area of about 0.06 km^2 and a maximum depth of 9.2 m, and it lies 450 m above sea level. The results showed that air & water temperature, dissolved oxygen and salinity readings were uniform through the lake profile and sampling times. Data also reflected high organic content and low concentrations of dissolved salt in southern direction. Gaber-Oun lake presented a meso-thermal profile varying from 19 ^{o}C at the surface to 31 ^{o}C at 2.5 m depth; more detailed studies will be necessary to establish the thermal characteristics of the lake. The lake has a high salinity which varies between 90 and 160 g/L. Humidity, nutrients and organic matter, may play significant role in the environmental stress which may lead to succession, through decomposition of organic matter and microbial activities to circulate nutrients. The vegetation diversity around the lake included 8 families divided in to 13 genus.

***Keywords*—**Sahara, Desert, Oases, Hyper-saline lake, Ecosystem, Succession, Ecology, Quber-Oun, Libya.

I. Introduction

GABER-Oun Lake is located 13^{o}30''N and 26^{o}51''E in the heart of the Sahara, about 115 km south west of the city of Sebha, Libya. The lake has an area of about 0.055 km^2 and a maximum depth of 9.2 m and it lies 450 m above sea level. The lake has a high salinity, which varies with sampling location and season. The salinity varies between 90 & 160 gm/L, with an average of 125 gm/L. This figure is more than 3.7 times higher than that for open seas and oceans, i.e. 33.5 gm/L, (Ajaili *et al.*, 1984). Hypersaline environments are generally defined as those containing salt concentrations in excess of seawater e.g., >35 gm/L. total dissolved salts, (Burns, et al., 2004). Most of the currently existing hypersaline bodies derive from the evaporation of seawater and are called thalassic. Athalassic waters are those in which the salts are of non-marine proportion, found for example after the concentration of sea water leads to precipitation of NaCl, leaving a high concentration of potassium and magnesium salts (Burns, *et al*., 2004). Hypersaline environments include closed drainage basin (endorheic) lakes where evaporation exceeds precipitation. This is the case in a group of ten relatively small lakes in Ramlat Az-Zallaf, Libyan Sahara. Gaber-Oun Lake is the biggest among 11 other lakes, which supports a unique hypersaline environment for many organisms (Ajaili *et al.*, 1984). Halophiles are salt-loving organisms that inhabit hypersaline environments. They include mainly living organisms with the capacity to balance the osmotic pressure of the environment and resist the denaturing effects of salts (Ventosa, et al., 1998). Generally, halophiles can be loosely classified as slightly, moderately and extremely halophilic, depending on their requirement for or tolerance of NaCl. Halophiles are found distributed all over the world in hypersaline environments, many in natural hypersaline brines in arid, coastal, and even deep-sea locations, as well as in artificial salterns used to mine salt from the sea (Gilmour, 1990).

Some researchers have proposed that the proportion of native species and plant diversity should be used to evaluate the success of restoration efforts Bradshaw (1996), Hobbs and Norton (1996), and Martin *et al.* (2005). Vegetation conservation and restoration of such regions is becoming of a significant concern, (Elssaidi & Almathnani, 2010 and Almathnani & Elssaidi, 2012).

II. Material And Methods

Libya is located in the arid central part of north Africa, where the annual rainfall average is less than 15 mm. Eleven different lakes some of them are permanent, others were temporary or extinct. Gaber-Oun oasis is one of them, it is surrounded by mobile sand dunes, aridity and biological scarcity. The oasis is surrounded by palm trees and reeds. The area was populated by local residents (300 capita during 1960's), when they evacuated in 1989. Real agriculture activities were experienced near the lake, where fresh ground water suitable for domestic purposes and irrigation, (Almathnani and Elssaidi 2012). Soil moisture and organic matter were determined near water bank, side edge and within the plants cover. organic matter were determined using Walkley-Black method, (Jackson, 1967). Different Plant Samples were collected for taxonomy and identification. Species were classified into different functional groups based on their growth form (Polley *et al.*, 2005). Qualitative and Quantitative characteristics of the vegetation including cover, height, number of individual species, functional groups and plant community were investigated in three 5×5 m quadrats which were randomly placed in each plot. Simpson's diversity index, Marglef's richness index, and the Pielou evenness index were calculated following the formulas cited by (Dong, 1997).The distance of plants growth to the external side all around the lake were measured according to (Badkevech, 1987). Plant heights were measured according to (Xiush, *et al.*, 1993). Stem thickness of plants species and plants residues weight (gm/m^2) were accordingly measured.

III. Results And Discussion

The climatic factors are the most supporting factors that affecting the plant succession in the desert lakes, (Kroplin, 2008). According to several environmental studies; wind, humidity and evapotranspiration were the most important factors that leading to ecological community matrix (Vannoordwijk, 1984). Data tabulated in TABLE 1 revealed that, air & water temperature, dissolved oxygen and salinity readings were uniform through sampling times and lake profile & directions.

The high evaporation and great transparency are responsible for the low temperature at water surface. More detailed studies will be necessary to establish the thermal characteristics of the lake. Nevertheless, it is important to point out that a similar thermal stratification pattern to data has also been recorded by (Salem & Benlaid 1987) when working on a shallow (2.85 m) hypersaline Maar lake near Pretoria. There, they found that the thermal stratification on the surface was transient, intensifying between morning and afternoon, and declining overnight.

TABLE 1
Daily Changes in Lake Water Natural Parameters

Site & parameters		Sampling time			
		9:00	*12:00*	*15:00*	*18:00*
North	Air temp,	17.0	25.0	18.0	13.0
	Water temp.	18.2	25.7	14.5	12.9
	DO	5.0	3.7	7.4	6.9
	Salinity	98.0	126.0	80.0	89.0
Middle	Air temp,	17.0	25.0	20.0	13.0
	Water temp.	18.3	24.0	20.4	18.0
	DO	6.6	3.9	7.5	7.0
	Salinity	120.0	133.0	136.0	110.0
South	Air temp,	17.0	25.0	21.0	13.0
	Water temp.	18.1	23.0	21.5	17.0
	DO	6.4	4.0	8.7	6.8
	Salinity	118.0	132.0	149.0	109.0

The differences in salinity readings between the surface and bottom waters were not appreciable and would be unlikely to influence phytoplankton and zooplankton distribution (Almathnani & Elssaidi, 2012). Soil parameters could affect the plants growth and its distribution, especially; humidity, nutrients and organic matter, TABLE 2. These factors may play significant role in the environmental stress that may leads to succession, through decomposition of organics matter and microbial activities to circulate nutrients, which leads to biological diversity.

TABLE 2
Organic Matter and Humidity of the Soils around Lake

Lake site	Soil Organic Matter (mg/Kg)			Soil Humidity (%)		
	Within plants	*Bank side*	*Shore side*	*Within plants*	*Bank side*	*Shore side*
North	2.21	1.81	1.98	14.96	18.84	20.57
West	6.40	4.99	-	15.50	16.50	-
South	5.66	5.47	1.21	15.45	14.32	16.70
East	4.99	5.34	3.64	16.85	17.11	20.71

The plant species found in different sites around the lake were tabulated in TABLE 3. Six plant families of higher plants were available around Gaber-Oun lake, they could be divided to thirteen species. The most common families were *Chenopodiaceae* and *Poaceae*, (3 sp, each) followed by *Tamaricaceae*, (2 sp.). Two tree species were imported to the area by the local resident, as they were not native plants, i.e.; *Eucalyptus rudris & Phoenix dactylifera*.

TABLE 3
Available Higher Plants in Qaber-Oun Ecosystem

FAMILY	SPECIES
Casuarinaceae	*Casuarina stricts*
Chenopodiaceae	*Hammada scoparia* *Traganum nudatum* Del. *Cornulaca monacantha* Del.
Cyperaceae	*Cyperus laevigatus* L
Myrtaceae	*Eucalyptus rudris*
Palmaceae	*Phoenix dactylifera* L.
Poaceae	*Phragmaties communis* *Arundo donax* L. *Imperata cylinderica* L.
Polygonaceae	*Calligonum comosum* L.
Tamaricaceae	*Tamarix aphylla* L. *Tamarix amplixicalis* L.

The most popular species and their distribution around the main lake were tabulated in TABLE 4. Date palm *Phoenix datylifera*, is the most common tree, where *Phragmitis australis* (Reed) & *Imperata cylimdrica* are the most dominant plants. The southern side of the lake was the most divers and plant cover area, where the human activities were concentrated. Such activities reflected a negative impacts on the lake ecosystem (fire, pollution and compaction of lake side soil by cars).

TABLE 4
Types and Distribution of Higher Plants around the Lake

Family	Species name	Distribution
Poaceae	*Phragmitis australis*	++++
Poaceae	*Imperata cylimdrica*	+++
Cyperaceae	*Cyperus laevigatus*	++
Tamaricaceae	*Tamarix aphylla*	+
Plamaceae	*Phoenix datylifera*	++++

The appearance of *Cyperus laevigatus* grass in any site indicated that this site reached the sedge meadow stage. *C. laevigatus* roots helps to aggregate the soil particles and accumulates organic matter, which support other plant seeds to germinate and that may lead to reeds disappearance; that was very clear in the western side of the lake. The appearance of *Tamarix aphylla* tree indicated shrubby stage of succession; it is halophyte tree helps to remediate the soil from salinity towards other types & cultivation.

The biological characteristics (*height, stem thickness, letters & distance of growth*) of the available plants around Gaber-Oun lake were shown in FIGURE 1. Data revealed that the vegetation growth was mostly concentrated in the eastern and southern side of the lake. Foliage litters was more accumulated in the eastern and southern direction, which lead to higher plant height, thickness and directional growth away from the water side. Reed reached the highest length, 3 meters from the water side at the southern sites; the location characterized by soft water leach and the oldest part of human activity. *Imperata cylinderica* showed the highest growth and height 3 meters from the water side at the northern site.

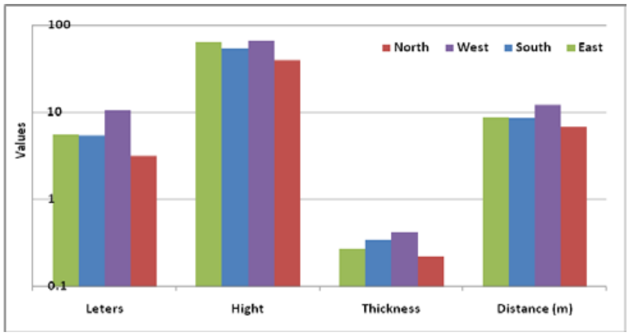

Fig. 1 Mean Plants Height (cm), Thickness (cm), Liters Weight (gm/m^2) and Expanding Distance (m).

The most favoured zone for plants growth is between 2-4 meters away from the water edges, FIGURE 2. That is may be because of humidity, low water salinity, and high organic matter content of the soil and microclimate condition due to the plant cover (relative humidity, low temperature & wind). That is very clear for *Phragmitis australis*, *Imperata Cylimdrica & Cyperus Laevigatus*, which showed higher growth density in all studied sites around the lake, more especially in the eastern site, TABLE 5.

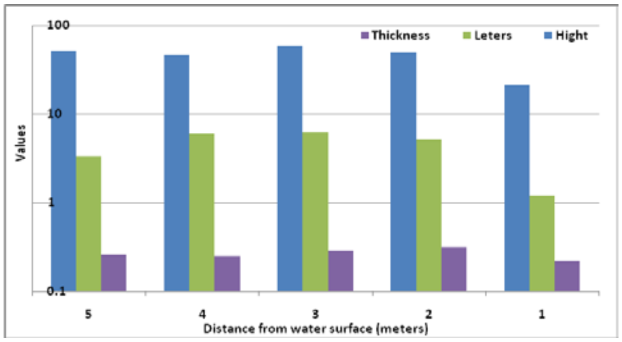

Fig. 2 Mean Plants Height (cm), Thickness (cm) and Liters Weight (gm/m^2) away from Water Body (m).

According to these results it could be concluded that Gaber-Oun lake passing through different succession stages, i.e., primary succession, forest and the matrix stages. The high organic matter composition encouraged the local people to cultivate some crops and planted different types of palm trees. That was clear from the high biomass content (137.6 gm/m^2) that enhanced microbial activities, i.e., increased the area biodiversity index. These findings were in agreements with several authors such as; (Richardson, 1977; Munawar, *et al.*, 1988; Martin and Paddy, 1994; Mathoka, 2000; Makahra, *et al.*, 2007 and Kropelin, *et al.*, 2008).

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TABLE 5
Abandance of the Available Plants Around the Lake

Lake Site	Distance from lake water edge (meters)												Abundancy rank
	0		1		2		3		4		5		
	Biomass	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass	Density	Biomass	Density	
North	0.0	0.0	34.8	52.3	23.5	35.3	14.1	19.5	44.5	66.5	23.4	34.7	*Phragmitis australis* *Cyperus Laevigatus* *Imperata Cylimdrica*
West	0.4	4.0	78.0	117.0	158.8	238.0	73.2	108.0	70.4	116.0	76.2	116.6	*Phragmitis australis*
South	0.5	3.5	69.5	91.3	150.3	226.3	79.9	62.0	73.2	115.7	74.6	81.7	*Phragmitis australis* *Imperata Cylimdrica* *Cyperus Laevigatus*
East	10.6	16.0	70.8	83.0	45.2	67.0	137.2	205.0	78.6	112.5	68.5	96.7	*Phragmitis australis* *Imperata Cylimdrica*