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Osmophilic/osmotolerant and halophilic/halotolerant mycobiota of soil of Wadi El-Natrun region, Egypt

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Abstract: Ninety- six samples of newly reclaimed soil were collected from around the main 8 lakes of Wadi El-Natrun region. Chemical analysis of these samples revealed that they are alkaline with pH 8.2–9.05, organic matter content from 0.3 to 2.0% and total soluble salts from 1.7 - 6.3%. Soil collected from Al Gaar Lake showed the highest levels of total soluble salts, potassium, sodium, calcium, magnesium carbonate, bicarbonate, and chlorides. On the other hand, some parameters showed their peaks in other lakes, such as sodium (11.1 mg/g) in Umm Risha, calcium (0.2 mg/g) in Hamra and magnesium (0.04 mg/g) in AL Beida. A total number of genera (31) and species and varieties (84+3) were recorded from soil samples collected from all lakes during the study on the three isolation media used, with the widest spectrum of species being isolated on Czapek´s medium (60+2) and the narrowest on 10% NaCl medium (41+1), whereas 40% sucrose medium was intermediate (49+2). *Aspergillus* (17+2 species varieties), *Fusarium* (14), *Myrothecium* (3), *Stachybotrys* (2), *Penicillium* (8) and *Emericella* (4) were regularly the most dominant genera possessing the highest proportions of propagules on the three isolation media. *Aspergillus niveus*, *Chaetomium globosum*, *C. olivaceum*, *C. monocereus*, *Fusarium poae*, *Scopulariopsis* (4 species), *Scytalidium lignicola* and *Thermoascus aurantiacus* were isolated only on 10% NaCl medium. *Aspergillus* showed its count peak in Khadra Lake on the control medium, in Fasida on 40% sucrose and 10% NaCl medium. *A. flavus*, *A. fumigatus*, *A. niger*, *A. ochraceus*, *A. sydowii* and *A. terreus*, in addition to *P. chrysogenum* and *F. solani* were common on all isolation media. *Emericella* and *Eurotium* were the most common genera on 40% sucrose. The data of the present study showed that the majority of fungal species recovered from soil around the 8 lakes of Wadi El-Natrun are osmotolerant/osmophilic and halotolerant/halophilic.

Key words: Alkaline soil around 8 lakes, Wadi El-Natrun, osmotolerant/osmophilic and halotolerant/halophilic fungi.

Introduction

Saline lakes are confined to dry regions of the world where evaporation exceeds precipitation. Wadi El- Natrun is considered among the important depressions in the Western Desert (El Ghani *et al.* 2014). Zahran and Willis (2009) reported the presence of 8 principal lakes for a distance of about 30 km; from south to north: Fasida, Umm Risha, Rosetta, Abu Gubara, Hamra, El Zugm, Al Beida, Khadra and Al Gaar, noting that Abu Gubara and Hamra form one lake in the summer. Wadi El-Natrun lakes are the native source of natron salt, which has been used in mummification techniques of ancient Egyptians.

Microbial mats commonly line the margin of saline lakes of Wadi El-Natrun (Taher 1999). Most microbial diversity studies in hypersaline environments (salterns) have focused on halophilic Archaea bacteria of the order Halobacteriales (Oren 2002). Other organisms such as algae, protozoa, eubacteria and even fungi are also found in the salterns (Cantrell *et al*. 2006).

Halophiles are salt-loving organisms that inhabit hypersaline environments. They can be loosely classified according to their salt requirement into 3 categories: slight halophiles, grow optimally at 0.2–0.85 mol/l (2–5%) NaCl, moderate halophiles grow optimally at 0.85–3.4 mol/l (5–20%) NaCl and extreme halophiles grow optimally above 3.4–5.1 mol/l (20–30%) NaCl (DasSarma and Arora 2001) . Halotolerant organisms can grow both in high salinity and in the absence of a high concentration of salts. *Gymnascella marismortui* was the first halophilic fungus to be isolated from the Dead Sea (Buchalo *et al.* 1999). The black yeasts and closely related dematiaceous *Cladosporium* were among the first halophilic fungi to have been isolated from salterns in Secovlje, Slovenia-Adriatic (Butinar *et al.* 2005). The isolation of other filamentous fungi from salterns (Cantrell *et al.* 2006), as well as from coastal environments of Arctics (Gunde-Cimerman *et al*. 2005) has followed.

Halophilic mycobiota were isolated from Mandovi estuary and dominated by *Aspergillus* and *Penicillium* species. *Aspergillus penicillioides* was isolated as obligate halophile.

All the isolates of *Penicillium, Cladosporium* and *Eurotium* were facultative halophiles (Gonsalves *et al.* 2012). Numerous studies have been made on species composition of fungi in saline soils of different regions and on their ability to grow on media with high salt concentration, which reported many halotolerant/halophilic species of the genera, namely *Aspergillus, Penicillium, Cladosporium, Fusarium, Geotrichum, Rhizopus, Mucor, Phoma* and *Trichoderma* (Ruiz-Suárez 2004, Steiman *et al.* 2004, Gunde-Cimerman *et al*. 2005 and Gashgari and Al- Hzmi 2006). The mycobiota of the saline Arubotaim Cave (on the southwestern shore of Dead Sea) contained a total of 68 species of 28 genera, where *Aspergillus* (17 species), *Penicillium* (9) and *Chaetomium* (8) were the most prevailing genera (Grishkan *et al.* 2003).

Osmophiles are microorganisms adapted to environments with high osmotic pressures, such as high sugar concentrations. Osmophiles are similar to halophiles because a critical aspect of both types of environment is their low water activity. High sugar concentrations represent a growth-limiting factor for many microorganisms, yet osmophiles protect themselves against this high osmotic pressure by the synthesis of osmoprotectants such as alcohols and amino acids (Fadl-Allah and Sayed 1991). Hamada and Yamada (1991) recorded *Wallemia sebi*, *Aspergillus restrictus* and *Eurotium* spp. as the most abundant osmophilic mycobiota of house dust.

Soil fungi in Egypt are generally osmophilic or osmotolerant (recovered on up to 50% sucrose agar), halophilic or halotolerant (recovered on 5% or more sodium chloride agar) (Moubasher *et al.* 1990). They may increase the concentration of sodium and chloride ions, and accumulate proline as an osmoregulator (Fadl-Allah and Sayed 1991).

The objective of this work is to highlight on the osmophilic/osmotolerant and halophilic/halotolerant fungi that may be found in the newly reclaimed soil around Wadi El-Natrun lakes.

Materials and Methods

Collection of soil samples

Samples of reclaimed soil, were collected during January 2006 – May 2007, from around the eight main lakes (Fasida, Umm-Risha, Rosetta, Hamra, El Zugm, Al Beida, Khadra, Al Gaar) of Wadi El-Natrun depression, Egypt. Ninety- six samples (12 from each lake) were collected randomly and put directly into clean plastic bags and brought into the laboratory and kept in a cold place (5°C) till chemical and fungal analysis.

Chemical analysis of soil samples

pH value: A pH meter (Orior Research Model GOHL Digital Ionalyzer) was used for the determination of soil pH. The electrode was immersed directly in the soil suspension with a ratio 1:5 (w /v) (Jackson 1958).

Organic matter content (OM%): A semi-quantitative method was used for the determination of organic matter involves the heated destruction of all organic matter in the soil (Astem 2000). OM% is calculated as the difference between the initial and final sample weights divided by the initial sample weight times 100%.

Total soluble salts (TSS): The specific electrical conductance was measured in the soil extract using the conductance meter (YSI, model 35). The percentage TSS in the samples were estimated using this equation: % TSS in the dry sample = 0.064 × EC × extract ratio. The conversion factor to percentage salts (0.064) fairly applied for solutions extracted from the soil (Jackson 1958).

Sodium and potassium (Na^+ & K^+): Flame photometer method (Williams and Twin 1960) using Carl Zeiss flame photometer was used for the determination of Na^+ and K^+ cations.

Carbonate and bicarbonate: Total carbonate and bicarbonate was determined directly in the soil through hydrochloric acid digestion according to the method described by Jackson (1958).

Calcium and magnesium (Ca^{+2} & Mg^{+2}): The versene (disodium dihydrogen ethylene diamine tetraacetic acid) titration method as recommended by Schwarzenbach and Biedermann (1948) was employed for Ca^{+2} and $Ca^{+2} + Mg^{+2}$ determination.

Chloride (Cl^-): Soluble chloride was estimated by applying the silver nitrate titration method using potassium chromate as an indicator (Jackson 1958).

Isolation of fungi from soil samples

The dilution- plate method was used for enumeration of different fungal species as described by Johnson and Curl (1972). One ml of the desired dilution was transferred aseptically into each of 5 Petri-dishes and ~20 ml / plate of one of the three media used cooled to just above solidifying temperature were poured. The dishes are rotated by hand in a broad swirling motion, so that the dilution soil is dispersed in the agar. After agar solidification, the plates were incubated at 28ºC for 3-4 weeks

during which the developing fungi were counted and isolated for further identification and the number of colony forming units (CFUs) was calculated per g soil sample.

The three types of media used for isolation of fungi were: 1) Modified Czapek's agar in which glucose (10 g/l) replaced sucrose, of the following composition (g/l) sodium nitrate 3.0, potassium dihydrogen phosphate 1.0, magnesium sulphate 0.5, potassium chloride 0.5, ferrous sulphate 0.01, glucose 10.0, agar 15.0), to which rose bengal (1/15000) and chloramphenicol (25 µg/ml) were added as bacteriostatic agents. This medium was used as a control medium; 2) Czapek's agar supplemented with 40% sucrose for isolation of osmophilic and osmotolerant fungi and 3) Czapek's agar medium supplemented with 10% sodium chloride was used for isolation of halophilic and halotolerant fungi.

Identification of fungi

The identification of fungal genera and species was based on macroscopic and microscopic features following the keys and descriptions of Ellis (1971), for Dematiaceous Hyphomycetes; Pitt (1979), for *Penicillium* and its teleomorphic states; Raper and Fennell (1965), for *Aspergillus* species; Leslie and Summerell (2006) and Ismail *et al.* (2015), for *Fusarium* species; Moubasher (1993) and Domsch *et al.* (2007), for fungi in general.

Statistical analysis

Hierarchical clustering analysis using free online software statistical analysis (www.wessa.nit.com) was.

Results and Discussion

Chemical analysis of soil samples

Chemical analysis of soil samples collected during January 2006 – May 2007 from around the 8 main lakes of Wadi El-Natrun showed that pH was alkaline ranging from 8.2 (in Khadra) to 9.05 (in Al Gaar) (Table 1). This is in agreement with the previous results obtained by Taher (1999) and Moussa *et al.* (2009) in Wadi El-Natrun Lakes (pH 8.51-9.45) and by Steiman *et al.* (2004) of Mono Lake of California (pH 9.4-9.8). El Ghani *et al.* (2014) reported lower levels of pH in soil around Wadi El- Natrun Lakes (7.65-7.75), but Grant *et al.* (2004) found that soil samples with soda crust collected from Umm Risha, Al Beida and Khadra Lakes had higher pH range (10-10.3). Organic matter (OM%) ranged from 0.3 in Al-Gaar to 2% in El Zugm Lake. These results showed almost higher values in organic matter content compared with the results obtained from different types of soil in Egypt and in some other Arab countries (Moubasher *et al.* 1990, El-Said and Saleem 2008). Total soluble salts (TSS%) was much lower in soil than in water (Moubasher *et al.* 2013), ranging from 1.7 (in Hamra) to 6.3% (in El-Zugm). In the study of Taher (1999) the concentration of TSS ranged from 2.83 g/l in Khadra to 557 g/l in Al- Beida Lake. The Dead Sea (Steiman *et al.* 1997) and the Great Salt Lake (Utah Geological Survey 2001) have similar salinities to those of Wadi El-Natrun lakes water, but their chemical composition is different.

Sodium cations ranged from 3.5 (mg/g) ± 2.3 in Rosetta to 11.1 ± 8.36 in Umm-Risha Lake; results disagreed with those reported by Moussa *et al.* (2009) who found higher sodium concentration of 954.0 mmol/l (=41.5 mg/ml) and Taher (1999) (30.2- 295.2 g/l). Potassium cation (K^+ mg/g. dry wt) fluctuated between 0.1 ± 0.01 (in Rosetta Lake) and 0.3 ± 0.1 in Al Gaar Lake. Carbonate (CO_3^{-2} mg/g. dry wt) anions ranged from 0.01 ± 0.2 in Al Beida Lake to 0.3 ± 0.03 in Al-Gaar Lake. Bicarbonate (HCO_3^- mg/g dry wt) ranged from 0.07 ± 0.04 in Umm Risha to 0.5 ± 0.5 in Al Gaar Lake. Calcium cation (Ca^{+2} mg/g dry wt) varied from 0.008 in Fasida to 0.2 ± 9.7 x 10^{-3} in Hamra Lake. Magnesium cations (Mg^{+2} mg/g dry wt) ranged from 0.01 in Khadra and Fasida to 0.04 ± 0.2 in Al Beida Lake. Chloride anions (Cl^- mg/g dry wt) ranged from 0.7 ± 0.1 in Al Hamara to 3.6 ± 2.5 in Al Gaar. Moubasher *et al.* (1990) recorded that the amount of carbonate, bicarbonate and chlorides in the soil samples collected from Egypt ranged between 0.07~5.4%, 0.14~5.88% and 0.18~5.94%, respectively.

From the above results, it is obvious that soil samples collected from Al Gaar Lake possessed the highest values of pH, total soluble salts, sodium, potassium, carbonate, bicarbonate and chloride compared to those collected from the other 7 lakes of Wadi El-Natrun. On the other hand, other parameters showed their peaks in different lakes e.g. organic matter (2.0±2.4) in El Zugm Lake, calcium (0.2±9.7x10^{-3}) in Hamra Lake, magnesium (0.04±0.2) in Al Beida and sodium (11.1±8.4 mg/g) in Umm Risha (Table 1). Compared with our findings, the results of El Ghani *et al.* (2014) revealed higher organic matter (2.17-6.55%), carbonates (2.93-21 mg/g), calcium (2.56-5.13 mg/g), magnesium (0.89-1.94 mg/g), sodium (4.16-47.66 mg/g), potassium (0.12-6.49 mg/g), bicarbonate (0.68-1.18 mg/g) as well as, chloride ions (3.11-35.59 mg/g).

Table 1: Chemical analysis of soil samples collected from around Wadi El-Natrun lakes.

Lake	Al-Gaar	Khadra	Al-Beida	El-Zugm	Hamra	Rosetta	Umm-Risha	Fasida
pH	9.05	8.2	8.7	8.5	8.7	8.4	8.5	8.3
OM%	0.3	1.2	1.4	2.0	1.4	1.3	1.7	0.7
TSS%	3.5	1.9	2.7	6.3	1.7	4.9	5.7	4.9
Na^{+}*	4.9±3.1	3.9±3.4	9.9±8.7	4.7±2.7	7.4±8.9	3.5±2.3	11.1±8.36	10.1±9.7
K^{+}*	0.3±0.1	0.14±0.05	0.15±0.1	0.16±0.08	0.25±0.1	0.1±0.01	0.13±0.03	0.2±0.3
CO_3^{-2}*	0.3±0.03	0.04±0.02	0.01±0.2	0.07±0.07	0.26±0.17	0.2±0.3	0.1±0.1	0.2±0.3
HCO_3^{-}*	0.5±0.5	0.1±0.07	0.2±0.2	0.1±0.1	0.1±0.08	0.26±0.3	0.07±0.04	0.2±0.2
Ca^{+2}*	0.01±0.01	0.03±0.03	0.03±0.02	0.01±0.1	$0.2\pm9.7\times10^{-3}$	0.02±0.01	0.01±0.01	0.008±0.0
Mg^{+2}*	0.023±0.01	0.01±0.01	0.04±0.2	0.02±0.01	0.03±0.02	0.02±0.01	0.03±0.03	0.01±1.4
Cl^{-} *	3.6±2.5	0.7±0.1	3.4±2.5	2±2.2	1±0.3	2.0±2.5	0.9±0.5	1.6±0.8

OM= Organic matter and TSS= Total soluble salts as percentage of dry soil, * = mg/g dry soil

Fungi isolated on Czapek's **agar**

Eighty-one species and 2 varieties related to 28 genera were recovered on Czapek´s agar (as control medium). *Aspergillus* (15 species), *Fusarium* (12), *Myrothecium* (3) *Stachybotrys* (2), *Penicillium* (7) and *Emericella* (5) were the most common genera. They accounted for between 5.75% - 46.38% of total fungi (Tables 2, 5). The highest total count was noted in soil around Umm Risha lake, while, the lowest was recorded in Fasida (Table 2).

From *Aspergillus, A. terreus, A. niger* and *A. flavus* were the most dominant *Aspergillus* species comprising 18.82, 12.07 and 8.29% of total fungi respectively and were reported in all lakes (Table 2). The highest count of *Aspergillus* was recorded in soil around Khadra Lake, while, the lowest was recorded in Rosetta lake. Other species, such as *A. deflectus* (from Rosetta), *A. parasiticus* (El Zugm), *A. parvulus* (Khadra), *A. pulverulentus, A. punicus* and *A. sydowii* (Hamra) were isolated from only one lake (Table 2). Ismail and Abdullah (1977) found that the most common fungi from alkaline (pH 8.1-8.6) soil around Basrah, Iraq belong to *Aspergillus* and *Penicillium*. Of *Aspergillus, A. niger, A. ochraceus, A. carneus, A. oryzae, A. wentii, A. versicolor, A. nidulans, A. terreus, A. flavus* and *A. fumigatus* were recorded. Also, Gomes *et al*. (2008) found also that *A. flavus, A. janus, A. japonicus, A. niger, A. sydowii* and *A. terreus* were the most common from the sand and water samples taken from alkaline soil at Casa Caiada and Bairro Novo beaches, Brazil. Abdel-Hafez *et al.* (2009) isolated *Aspergillus* and *Penicillium* in high frequency of occurrence from salt marsh soils in Egypt and found *A. flavus, A. fumigatus, A. niger* and *A. ochraceus* to be the most common.

The peak of *Fusarium* was detected in soil around Umm Risha. *F. solani* (4.19% of total fungi) was recorded from all lakes. *F. equiseti* (from El Zugm), *F. subglutinans* (Umm Risha) and *F. tumidum* (from Hamra) were isolated each from one lake. In agreement with our results, Abdel-Hafez *et al.* (2009) isolated 17 *Fusarium* species from salt marsh soils, of which *F. solani* was the most common. Gomes *et al.* (2008) isolated *Fusarium solani, F. dimerum, F. equiseti* and *F. oxysporum* from alkaline soil in Brazil, of which *F. solani* was also the most common.

Stachybotrys (*S. chartarum* and *S. kampalensis*) was recorded from all lakes accounting for 6.74% of total fungi. The peak of *Stachybotrys* was recorded from Al Gaar Lake. In this respect, *S. chartarum* was isolated from the alkaline soil (pH 8.1-8.6) around Basrah, Iraq (Ismail and Abdullah 1977) and was of high frequency of occurrence in the sandy soil of Egyptian beaches (Migahed 2003).

Penicillium (5.75% of total fungi) and its dominant species (*P. chrysogenum,* 2.42%) were recorded from all lakes except Fasida. Migahed (2003) isolated *P. chrysogenum* and *P. citrinum* with high frequency from the sandy soil of Egyptian beaches, while Ismail and Abdullah (1977) isolated *Penicillium notatum, P. lilacinum, P. corymbiferum* and *P. crustosum* from the alkaline soil around Basrah, Iraq.

Emericella (7.92% of total fungi) was recorded from all lakes, while its dominant species, *E. nidulans* (3.7%), was detected from all lakes except Al Beida and *E. quadrilineata* (3.52%) from all lakes except Khadra and Umm Risha Lakes. *E. lata* was recorded from three lakes (Khadra, El Zugm and Rosetta), while *E. acristata* was recorded from 2 lakes (Table 2). *Emericella nidulans* is a typical soil fungus and was isolated from desert and saline soil (Moustafa 1975). However, it was isolated in rare frequency from Casa Caiada and Bairro Novo beaches, Brazil (Gomes *ei al.* 2008). *Myrothecium verrucaria* was isolated from all

lakes, while *M. roridum* was recorded from 4 lakes and *M. striatisporum* from 3 lakes.

The remaining genera were less commonly isolated from 5 lakes (*Acremonium*, *Alternaria*, *Humicola*), 4 lakes (*Cochliobolus* and *Setosphaeria*), 2 lakes (*Rhizopus*, *Chaetomium*, *Scopulariopsis*, *Trichoderma*) or one lake (*Phialophora* sp., *Phoma* sp., *Talaromyces* sp. and *Ulocladium botrytis*) (Table 2,5). In this respect, Ismail and Abdullah (1977) isolated *Acremonium strictum*, *Alternaria alternata*, *Botryotrichum piluliferum*, *Drechslera spicifera*, *Myrothecium roridum*, *Stachybotrys chartarum*, *Ulocladium botrytis*, *U. atrum* and *U. chartarum* from alkaline soil around Basrah, Iraq. Steiman *et al*. (1997) found species of Ascomycetes, *Sporormiella minima*, *S. minimoides*, and the hyphomycetes *Acremonium strictum*, *Alternaria alternata*, *A. chlamydospora*, *Aphanocladium album*, *Aspergillus fumigatus*, *A. niger*, *Botryotrichum piluliferum*, *Botrytis cinerea*, *Cladosporium cladosporioides*, *Gliocladium roseum*, *Penicillium aurantiacum*, *P. chrysogenum*, *P. griseoroseum*, *P. purpurogenum*, *P. simplicissimum* in both oases and in desert zones of Ein Gedi and Einot Zugim of Dead Sea area. Also, Abdel-Hafez *et al*. (2009) isolated species of *Botryotrichum*, *Chaetomium*, *Cladosporium*, *Curvularia*, *Cylindrocarpon*, *Humicola*, *Rhizopus*, *Setosphaeria*, *Stachybotrys*, *Stemphylium*, *Thamnidium*, *Trichothecium* and *Ulocladium* from salt marsh soil, in Egypt. *Chaetomium* was also significantly represented in soil of the Dead Sea area (13 species, Steiman *et al*. 1997) and in the salt marshes of Kuwait (8 species, Moustafa, 1975).

Fungi isolated on Czapek´s agar supplemented with 40% sucrose or 10% NaCl

It should be admitted that the present results do not draw a sharp demarcation between osmotolerant and osmophilic or between halotolerant and halophilic fungi. Therefore they are treated as one category viz. osmotolerant / osmophilic or halotolerant / halophilic compared to those on Czapek (Cz). Fifty-eight species and 2 varieties assigned to 18 genera of osmotolerant/osmophilic fungi were recovered on Czapek's + 40% sucrose agar compared to 44 species and one variety related to 16 genera of halotolerant/halophilic fungi recovered on Czapek's + 10% NaCl agar were identified from soil around 8 lakes of Wadi El-Natrun. These results when compared to 81 species and 2 varieties on Czapek's (Cz) related to 28 genera reveal that the majority of fungi of Wadi El-Natrun are osmotolerant/osmophilic and halotolerant/halophilic. They are able to accommodate themselves to exist under conditions of water stress of the two media but a lower number can tolerate water stress when combined with the toxic effect of excessive concentration of Na^+ and Cl^- ions. The most significant observations of this part (Tables 2, 3, 4 and 5) were:

1. ***Aspergillus*** **(17 spp. + 2 varieties)** was consistently the most frequent genus (100% frequency), and the most dominant, regularly contributing the highest CFU's on the three media, but Czapek's + 40% sucrose agar sustained the highest count and Cz + 10 NaCl the lowest. *A. terreus*, *A. flavus* , *A. níger*, *A. ochraceus*, *A. sydowii*, *A. terreus* var. *africanus*, *A. ustus* and *A. fumigatus* were represented on the three media, but *A. terreus* was regularly the most dominant contributing the highest numbers on the three media but the optimum one was Cz + 40% sucrose. *A. flavus* showed its highest frequency on Cz agar, but *A. níger* and *A. fumigatus* on 40% sucrose.
2. ***Eurotium*** **(2 spp.)** the real osmophilic and halophilic genus was regularly encountered on the three media, but the optimum medium was 40% sucrose for the highest frequency (81.3%) and *E. chevalieri* was the dominant species of the genus.
3. ***Emericella*** **(4 spp.)** was absent on 10% NaCl and its maximum frequency and count were recorded on 40% sucrose. *E. nidulans* and *E. quadrilineata* were the dominant species on 40% sucrose.
4. ***Fusarium*** **(14 spp.)** was regularly recovered on all media but its highest frequency on 40% sucrose and the best count on 10% NaCl. *F. solani*, *F. oxysporum*, *F. sambucinum* and *F. semitectum* were regularly isolated on the three media. *F. solani*, *F. oxysporum* and *F. semitectum* were more frequent on Cz, but *F. sambucinum* was more frequent on 40% sucrose. *F. poae* was only encountered on 10% NaCl.
5. ***Penicillium*** **(8 spp.)** was identified on all media but the best frequency and count were registered on 40% sucrose. *P. chrysogenum* exhibited its best frequency and count on 40% sucrose, but was absent on 10% NaCl.
6. ***Scopulariopsis*** **(6 spp.)** was isolated on the three media, but its highest frequency and count were recorded on 10% NaCl. *S. brevicaulis* was encountered on the three media but its highest frequency on 40% sucrose. *S. brumptii* exhibited its highest frequency on NaCl but was absent on Cz. *S. halophilica* was recovered on NaCl only.
7. ***Cladosporium*** **(3 spp.)** was recovered on the three media; it showed its best frequency on 40% sucrose. *C. cladosporioides* was the

most frequent species on Cz and 40% sucrose, but was absent on 10% NaCl, whereas *C. oxysporum* was regularly recovered on the three media.

8. ***Acremonium* (4 spp.)** was regularly isolated on the three media. *A. furcatum* exhibited its highest frequency on 10% NaCl, followed by 40% sucrose and Cz. *A. strictum* showed its highest frequency on 10% NaCl followed by the control medium and absent on 40% sucrose. *Acremonium* was with relatively higher frequency in the soil of Wadi El-Natrun than in the other surveys in Egypt in the last century (Moubasher, 1993).
9. **On Cz** the highest frequency (100%) among genera was recorded for *Aspergillus* and the runner-up was *Stachybotrys* (80.2%), followed by *Fusarium* (76%) and *Penicillium* (62.5%). The highest records for species frequency were held to *A. terreus* (85.4%), *A. flavus* (83.3%), *S. chartarum* (80.2%) and *A. niger* (78.1%).

   On 40% sucrose, the highest record of frequency was held to *Aspergillus* (95.8%), *Eurotium* (81.3%), *Fusarium* (79.2%), *Emericella* (78.1%), *Penicillium* (68.8%), *Stachybotrys* (42.7%). The highest frequencies among species were recorded for *A. terreus* (89.6%), *A. niger* (81.3%), *S. chartarum* (80.2%), *A. flavus* (79.2%), *Eurotium chevalieri* (77.1%), *E. nidulans* (59.4%) and *P. chrysogenum* (58.3%).

   On 10% NaCl, the runner–up of *Aspergillus* (46.9% frequency) was *Penicillium* (36.5%), followed by *Scopulariopsis* (34.4%), *Eurotium* (30%) and *Fusarium* (22.9%). The most prevalent species was *A. terreus* (44.8%), followed by *A. sydowii* (34.4%), *Eurotium chevalieri* (30.0%), *S. brumptii* (29.2%) and *S. halophilica* (22.9%).

   Cz sustained the broadest spectra of genera (26) and species (60), and 10% NaCl the narrowest (16 and 41 respectively).

   In the literature a great number of fungi recorded in the present investigation on 40% sucrose and 10% NaCl media were also identified in different parts of the world on high sugar concentrations, from sand dunes and house dust samples in Saudi Arabia (Bakhary 1999); sand soil of Egyptian beaches (Migahed 2003); and dry fruits (Srivastava *et al.* 2014); and on high salt concentrations from Mayaguez Bay shoreline, western Puerto Rico (Rusi-Suarez 2004), saline soils (Steiman *et al*. 1997), the Arubotaim Caves, one of the Holocene Karst Caves developed within the salt body of Mount Sodom, the south western part of the Dead Sea (Grishkan *et al.* 2004) and hypersaline Dead Sea shore (Grishkan *et al.* 2003), the Red Sea shore (Abol-Nasr 1981), salt marsh soil in Egypt (Moubasher *et al.* 1990), solar salterns (Cantrell *et al.* 2006), saline environments in Slovenia (Butinar *et al.* 2005), hypersaline environment of solar salterns and hypersaline lakes worldwide (Gunde-Cimerman *et al.* 2005), and Mondovi estuary (Gunde-Cimerman *et al.* 2009 and Gonsalves *et al.* 2012).

Cluster analysis of the diversity of fungal species of the soil around the eight lakes

On Czapek´s agar (Figure 1), the analysis showed that Rosetta and Al Gaar lakes were clustered together in group (A), which possessed the highest values of TSS% (4.9 and 3.5% respectively). Also Fasida and Al Beida were clustered in group (B) and closely related to group (A). Both lakes had the same content of HCO_3^- (0.2 mg/g) and almost similar Na^+ concentrations (10.1 and 9.9 mg/g respectively) (Table 1).

On Czapek's 40% sucrose agar, The cluster analysis classified lakes into four groups: group (A), included Umm Risha and Khadra Lakes which possessed almost similar contents of K^+ (0.13 and 0.14 mg/g respectively). While group (B), included El Zugm and Al Gaar Lakes, which had almost similar Na^+ content (4.7, 4.9 mg/g respectively) and group (C), including Fasida and Al Beida Lakes which are closely related (Figure 2).

On Czapek's 10% NaCl, the cluster analysis in Figure (3) showed two closely-related groups including Rosetta, El Zugm and Fasida Lakes (group A), Cl^- contents very-close ranging from 1.6 to 2.0 mg/g and Al Beida and Al Gaar Lakes (group B) with Cl^- contents of 3.4-3.6 mg/g (Table 1). In contrast, Khadra Lake was separated from the other lakes in a separate clade which recorded the least pH value (8.2) and Cl^- content (0.7 mg/g).

Table 2: Percentage total counts (TC%) and Percentage frequencies (F%, out of 12 samples) of fungal taxa recorded from soil samples collected from each of the 8 Lakes of Wadi El- Natrun on Czapek´s agar at 28°C.

Fungal taxa	Al Gaar		Khadra		Al Beida		El Zugm		Hamra		Rosetta		Umm Risha		Fasida		Total	
	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%
Aspergillus	36.32	100	64.55	100	54.55	100	36.99	100	42.38	100	32.42	100	51.57	100	52.22	100	46.38	100
A. terreus	23.63	100	30.78	83.3	11.91	33.3	11.02	100	14.69	83.3	13.64	83.3	36.00	100	8.87	100	18.82	85.4
A. flavus	6.98	83.3	0.71	50	17.98	100	18.89	66.7	1.95	83.3	5.42	83.3	6.98	100	7.39	100	8.29	83.3
A. niger	4.07	83.3	2.86	33.3	19.93	83.3	4.86	66.7	18.87	83.3	8.57	100	8.34	75	29.06	100	12.07	78.1
A. fumigatus	0.47	16.7			3.37	33.3	0.44	50	0.65	50	2.06	33.3					0.87	22.9
A. ochraceus	0.47	16.7			1.35	16.7			3.68	50			0.26	25			0.72	13.5
Stachybotrys	14.09	100	3.46	100	11.13	50	9.34	100	2.62	83.3	6.87	83.3	4.43	75	1.97	50	6.74	80.2
S. chartarum	14.09	100	3.46	100	11.13	50	9.34	100	2.62	83.3	6.51	83.3	4.43	75	1.97	50	6.69	80.2
Fusarium	8.15	33.3	8.54	83.3	12.74	66.7	15.49	100	18.68	100	21.01	100	27.57	75	2.96	50	14.39	76.0
F. solani	1.63	33.3	0.76	33.3	5.99	50	0.59	33.3	9.82	100	11.50	83.3	0.26	25	2.96	50	4.19	51.0
Fusarium spp.	1.40	16.7	6.86	33.3	6.44	33.3	11.13	83.3	0.01	33.3	5.50	100					3.92	37.5
F. oxysporum	3.49	16.7					0.20	33.3	1.31	33.3	1.07	50	5.70	75			1.47	26.0
F. semitectum			0.38	33.3					0.22	33.3	0.18	33.3	16.17	75			2.12	21.9
Penicillium	1.86	50	8.39	83.3	16.45	83.3	4.68	83.3	4.04	83.3	6.68	66.7	3.91	50			5.75	62.5
P. chrysogenum	0.47	16.7	0.38	33.3	7.42	16.7	2.31	50	1.78	66.7	3.96	50	3.06	33.3			2.42	33.3
P. funiculosum			6.52	50					0.22	33.3	0.41	33.3	0.17	25			0.91	17.7
P. duclauxii			0.57	33.3	0.34	16.7	0.89	33.3					0.68	33.3			0.31	14.6
Myrothecium	15.37	33.3	6.78	100	2.25	16.7	1.42	50	3.29	83.3	1.38	50	2.38	75	14.78	50	5.96	57.3
M. verrucaria	15.37	33.3	6.39	100	2.25	16.7	0.83	50	3.00	83.3	0.28	33.3	0.34	50	4.43	50	4.11	52.1
M. roridum			0.19	33.3			0.59	33.3	0.29	33.3			2.04	75			0.39	21.9
Emericella	7.22	33.3	3.05	33.3	0.34	16.7	21.48	100	6.69	83.3	9.10	50	0.26	25	15.27	100	7.92	55.2
E. nidulans	4.42	33.3	2.86	33.3			13.52	100	1.87	66.7	3.19	50	0.26	25	3.45	50	3.70	44.8
E. quadrilineata	2.79	16.7			0.34	16.7	3.32	66.7	4.17	66.7	5.72	50			11.82	100	3.52	39.6
Humicola							3.20	83.3	6.53	33.3	1.68	50	0.26	25	8.87	100	2.57	36.5
H. grisea							3.20	83.3			1.68	50	0.26	25	4.93	100	1.26	32.3
Gliocladium roseum	2.33	16.7	0.95	33.3	0.45	16.7			2.18	33.3	3.69	50	0.77	25	0.49	50	1.36	28.1
Alternaria	1.16	16.7	0.57	33.3	0.22	16.7	0.49	33.3	1.31	33.3			1.28	25			0.63	19.8
Total counts	85900		209860		88967		135083		183811		145411		352500		81200		1282733	
No. of genera	11		10		11		15		16		16		13		10		26	
No. of species+varieties	16+1		21+1		15		26+1		35		26		25		15+1		60+2	

Results of genera and species recovered from one or two lakes only were omitted from the table.

Table 3: Percentage total counts (TC%) and Percentage frequency (F%, out of 12 samples) of fungal taxa recorded from soil samples collected from each of the 8 Lakes of Wadi El- Natrun on Czapek´s agar supplemented with 40% sucrose (40%S) at 28°C.

Fungal taxa	Al Gaar		Khadra		Al Beida		El Zugm		Hamra		Rosetta		Umm Risha		Fasida		Total	
	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%
Aspergillus	39.14	66.7	59.55	100	55.49	100	28.52	100	52.53	100	40.20	100	58.80	100	67.74	100	51.81	95.8
A. terreus	29.95	50	28.71	100	30.29	83.3	18.03	100	16.79	100	20.63	83.3	38.51	100	38.02	100	24.76	89.6
A. niger	3.59	66.7	6.30	100	9.92	66.7	4.27	50	27.80	100	15.56	66.7	11.18	100	20.74	100	12.01	81.3
A. flavus	5.06	33.3	2.20	83.3	10.18	83.3	2.83	66.7	5.26	83.3	2.94	83.3	8.70	100	2.76	100	5.50	79.2
A. fumigatus	0.53	16.7	2.06	50	2.11	16.7	3.39	33.3			0.43	33.3	0.41	25	3.46	100	1.37	34.4
A. sydowii			8.23	50	1.58	33.3					0.64	33.3			1.38	50	1.58	20.8
Eurotium	12.78	100	8.48	83.3	5.09	66.7	15.71	83.3	16.50	83.3	13.34	83.3	6.00	100	0.46	50	9.28	81.3
E. chevalieri	11.18	83.3	7.48	83.3	4.04	66.7	12.21	83.3	4.30	66.7	10.14	83.3	6.00	100	0.46	50	6.91	77.1
E. amstelodami	1.60	33.3	1.00	33.3	0.35	16.7	3.05	33.3	12.20	33.3	3.20	33.3					2.25	22.9
Fusarium	11.72	83.3	7.73	83.3	12.47	83.3	5.29	66.7	1.45	33.3	5.79	83.3	16.36	100	8.29	100	9.74	79.2
F. solani	5.86	33.3	2.09	66.7	6.50	50	1.02	33.3			4.83	83.3	1.04	50	6.91	50	2.91	45.8
F. verticillioides	2.59	50	4.64	83.3	0.26	16.7			1.45	33.3			1.24	25			1.20	26.0
F. sambucinum			0.50	33.3	5.71	33.3					0.32	33.3	0.83	25			0.94	15.6
Emericella	24.76	83.3	8.38	83.3	8.78	50	36.98	100	13.31	83.3	16.53	100	2.17	25	20.74	100	13.46	78.1
E. quadrilineata	16.51	83.3			5.97	33.3	12.00	83.3	11.32	83.3	11.93	83.3	0.62	25	11.06	100	6.68	61.5
E. nidulans	8.25	66.7	6.13	83.3	2.46	33.3	9.16	66.7	2.00	50	4.61	50	1.55	25	8.29	100	4.57	59.4
Penicillium	9.34	100	6.28	66.7	13.17	66.7	3.46	50	9.53	83.3	19.16	83.3	13.77	100			10.24	68.8
P. chrysogenum	6.66	83.3	6.28	66.7	3.51	33.3	2.44	50	3.43	66.7	1.28	66.7	9.01	100			4.95	58.3
P. puberulum	1.33	33.3			0.70	16.7	1.02	33.3	5.01	66.7	0.64	33.3	2.69	100			1.59	35.4
P. funiculosum					0.70	16.7			0.36	33.3	0.64	33.3	0.72	50			0.38	16.7
P. citrinum	0.01	16.7			0.35	16.7					14.97	33.3	1.35	50			2.13	14.6
Stachybotrys chartarum			4.49	66.7			5.29	50	1.13	50	0.51	50	1.45	75	0.46	50	1.85	42.7
Cladosporium	1.20	16.7	1.00	50			1.36	33.3	1.09	66.7	1.60	50	2.03	25	0.46	50	0.71	36.5

Fungal taxa	Al Gaar		Khadra		Al Beida		El Zugm		Hamra		Rosetta		Umm Risha		Fasida		Total	
	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%
C. cladosporioides	1.20	16.7	0.50	33.3			1.36	33.3	0.36	33.3			2.03	25	0.46	50	0.38	20.8
Total Counts	75114		160413		113900		117959		110167		125079		289800		86801		1079233	
No. of genera	7		12		8		10		11		11		9		10		18	
No. of species+varieties	19		22+1		24		17		21+1		21		23		18		49+2	

Results of genera and species recovered from one or two lakes only are omitted from the table.

Table 4: Percentage total counts (TC%) and Percentage frequencies (F%, out of 12 soil samples) of fungal taxa recorded from soil samples collected from each of the 8 Lakes of Wadi El- Natrun on Czapek´s agar supplemented with 10% NaCl at 28°C.

Fungal taxa	Al Gaar		Khadra		Al Beida		El Zugm		Hamra		Rosetta		Umm Risha		Fasida		Total	
	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%	TC%	F%
Aspergillus	55.38	50	5.91	33.3			69.79	33.3	20.09	66.7	72.58	66.7	46.86	75	91.42	50	34.49	46.9
A. terreus	19.69	33.3	3.73	33.3			64.64	33.3	11.48	66.7	41.21	66.7	42.39	75	39.28	50	23.91	44.8
A. sydowii	1.84	16.7	1.16	33.3			1.74	33.3	0.39	50	2.77	66.7	0.38	75			0.84	34.4
A. flavus	27.56	50					2.85	16.7	1.45	50	25.27	50	2.35	50	11.06	50	4.16	33.3
A. ochraceus	1.05	16.7	0.87	33.3			0.37	33.3	5.51	50	0.51	50	1.36	50			1.86	29.2
A. carneus	2.62	16.7					0.19	16.7	0.55	33.3	2.82	33.3	0.38	25			0.50	15.6
Penicillium	3.41	33.3	0.70	33.3					0.49	66.7	5.13	83.3	0.38	75			0.85	36.5
P. puberulum	3.41	33.3							0.49	66.7	2.77	66.7	0.30	50			0.48	27.1
Scopulariopsis	33.60	33.3			100.00	50	24.24	33.3	3.36	50	16.10	33.3	0.15	25	4.90	50	5.26	34.4
S. brumptii	24.15	33.3			62.07	50	20.51	33.3	2.46	33.3	10.76	33.3			4.90	50	3.79	29.2
S. halophilica	9.45	33.3			36.55	50	3.73	33.3	0.90	33.3	0.51	33.3					1.10	22.9
Eurotium	1.57	16.7	0.29	33.3			1.12	33.3	0.98	50	1.28	33.3	0.38	25	3.69	50	0.75	30.2
E. chevalieri	0.79	16.7	0.29	33.3			0.75	33.3	0.57	50	0.77	33.3	0.38	25	3.69	50	0.60	30.2
E. amstelodami	0.79	16.7					0.37	33.3	0.41	33.3	0.51	33.3					0.16	14.6
Total Counts	762		6874		290		1072		4877		1561		7926		1139		24486	
No. of genera	7		4		1		5		9		6		12		3		16	
No. of species+varieties	16		6+1		3		12		16		18		24		5		41+1	

Results of genera and species recovered from one or two lakes only are omitted from the table.

Table 5: Percentage total counts (TC%) and percentage frequencies (F%, out of 96 soil samples) of fungal taxa recorded from 96 soil samples collected from 8 lakes on Czapek's agar (Cz), Czapek´s supplemented with 40% sucrose or 10% NaCl at 28°C.

Fungal taxa	Cz		40% S		10% NaCl	
	TC%	F%	TC%	F%	TC%	F%
Acremonium Link	1.05	27.1	0.51	16.7	2.47	11.5
A. curvulum W. Gams	0.05	4.2				
A. furcatum Moreau & Moreau ex Gams	0.14	4.2	0.40	6.3	0.14	7.3
A. kiliense Gütz	0.05	4.2				
A. strictum W. Gams	0.16	4.2			0.16	7.3
Acremonium sp.	0.64	18.8	0.11	12.5	2.18	4.2
Alternaria Nees: Fries	0.63	19.8			0.14	5.2
A. alternata (Fries) Keissler	0.12	7.3			0.07	3.1
A. tenuissima (Kunze: Fries) Wiltshire	0.06	3.1			0.07	5.2
Alternaria sp.	0.45	14.6				
Aspergillus P. Micheli ex Link	46.38	100	51.81	95.8	34.49	46.9
A. aureolatus Munt., Cvet. & Bata	0.16	8.3				
A. candidus Link			0.04	4.2		
A. carneus Blochwitz			0.06	2.1	0.50	15.6
A. deflectus Fennell & Raper	0.34	4.2				
A. flavus Link	8.29	83.3	5.50	79.2	4.16	33.3
A. flavus var. c*olumnaris* Raper & Fennell	0.05	6.3				
A. fumigatus Fresenius	0.87	22.9	1.37	34.4	0.08	2.1
A. niger van Tieghem	12.07	78.1	12.01	81.3	0.05	4.2
A. niveus van Tieghem					0.09	4.2
A. ochraceus Wilhelm	0.72	13.5	0.26	12.5	1.86	29.2
A. parasiticus Speare	0.15	4.2				
A. parvulus Smith	0.02	4.2				
A. pulverulentus (Mcalpine) Thom	0.03	4.2				
A. puniceus Kwon & Fennell	0.05	4.2				
A. sydowii (Bainier & Sartory) Thom & Church	0.19	9.4	1.58	20.8	0.84	34.4
A. terreus Thom	18.82	85.4	24.8	89.6	23.91	44.8
A. terreus var. *africanus* Fennell & Raper	3.18	10.4	5.99	4.2	1.09	6.3
A. ustus (Bainier) Thom & Church	1.43	10.4	0.11	6.3	1.91	6.3
A. versicolor(Vuillemin) Tiraboschi			0.14	6.3		
Botryotrichum sp.	0.04	4.2				
Chaetomium Kunze	0.63	14.6			1.00	3.1
C. globosum Kunze					0.44	3.1
C. olivaceum Cooke & Ellis					0.56	3.1
Chaetomium sp.	0.63	14.6				
Cladosporium Link	2.07	25.0	0.71	36.5	0.08	7.3
C. cladosporioides (Fresenius) de Vries	0.54	9.4	0.38	20.8		
C. oxysporum Berkeley & Curtis	0.44	7.3	0.07	8.3	0.03	4.2
C. sphaerospermum Penzig	0.06	6.3			0.05	3.1
Cladosporium spp.	1.03	8.3	0.26	6.3		
Cochliobolus Drechsler	0.32	18.8	0.33	14.6	0.07	4.2
C. australiensis (Tsuda & Ueyama) Alcorn	0.05	4.2	0.33	14.6		
C. monocereus Alcorn					0.03	4.2

Fungal taxa	Cz		40% S		10% NaCl	
	TC%	F%	TC%	F%	TC%	F%
C. spicifer Nelson	0.23	12.5				
C. tuberculatus Sivanesan	0.05	4.2			0.03	4.2
Curvularia lunata var. *aeria* (Balista, Lima & Vasconcelos) M. B. Ellis			0.04	4.2		
Cylindrocarpon sp.			0.06	2.1		
Emericella Berkeley & Broome	7.92	55.2	13.46	78.1		
E. acristata (Fennell & Raper) Subrananiam	0.30	8.3	0.28	10.4		
E. lata Subramanian	0.33	12.5	1.26	12.5		
E. nidulans (Eidam) Vuillemin	3.70	44.8	4.57	59.4		
E. quadrilineata (Thom & Raper) Benjamin	3.52	39.6	6.68	61.5		
Emericella sp.	0.07	4.2	0.67	12.5		
Eurotium Link	1.11	15.6	9.28	81.3	0.75	30.0
E. amstelodami Mangin			2.25	22.9	0.16	14.6
E. chevalieri Mangin	0.10	9.4	6.91	77.1	0.60	30.0
Eurotium spp.	1.01	6.3	0.12	6.3		
Fusarium Link	14.39	76.0	9.74	79.2	0.07	22.9
F. chlamydosporum Wollenweber & Reinking	0.19	8.3			36.30	22.9
F. equiseti (Corda) Saccardo	0.20	6.3				
F. lateritium Nees			0.07	4.2	0.07	4.2
F. oxysporum Schlechtendal	1.47	26.0	0.22	7.3	6.78	7.3
F. poae (Peck) Wollenweber					1.63	4.2
F. proliferatum (Matsushima) Nirenberg	0.07	6.3	0.22	3.1		
F. sambucinum Fuckel	0.77	10.4	0.94	15.6	25.49	12.5
F. semitectum Berk. & Rav	2.12	21.9	3.24	16.7	1.59	9.4
F. solani (Martius) Saccardo	4.19	51.0	2.91	45.8	0.67	14.6
F. sporotrichioides Sherbakoff			0.30	6.3		
F. subglutinans (Wollenweber & Reinking) Nelson *et al*	0.62	9.4	0.06	3.1		
F. tricinctum (Corda) Saccardo	0.06	9.4				
F. tumidum Sherb.	0.35	4.2				
F. verticillioides (Saccardo) Nirenberg	0.43	17.7	1.20	26.0		
Fusarium spp.	3.92	37.5	0.58	10.4	0.07	2.1
Gliocladium Corda.	1.36	28.1	0.11	10.4		
G. catenulatum Gilman & Abbott			0.04	6.3		
G. roseum Bainier	1.36	28.1	0.07	4.2		
Humicola Traaen.	2.57	36.5	0.04	6.3		
H. fuscoatra Traaen.	1.31	16.7				
H. grisea Traaen.	1.26	32.3	0.04	6.3		
Myrothecium Tode	5.96	44.8	0.59	29.2	5.72	4.2
M. roridum Tode	0.39	21.9				
M. striatisporum Preston	1.45	14.6	0.15	10.4		
M. verrucaria (Albertini & Schweinitz) Ditmar	4.11	44.8			5.72	4.2
Nectria sp.	0.04	2.1	0.44	18.8		
Paecilomyces variotii Bainier			0.14	6.3		
Penicillium Link	5.75	62.5	10.24	68.8	0.85	36.5
P. chrysogenum Thom	2.42	33.3	4.95	58.3		
P. citrinum Thom			2.13	14.6	0.06	7.3

Fungal taxa	Cz		40% S		10% NaCl	
	TC%	F%	TC%	F%	TC%	F%
P. duclauxii Delacroix	0.31	14.6	0.20	6.3		
P. expansum Link			0.07	2.1		
P. funiculosum Thom	0.91	17.7	0.38	16.7		
P. pinophilum Hedgcock	0.05	4.2	0.46	10.4		
P. puberulum Bainier	0.13	8.3	1.59	35.4	0.48	27.1
P. purpurgenum Stoll	0.08	4.2	0.17	10.4		
Penicillium spp.	1.85	33.3			0.31	10.4
Phialophora sp.	0.05	4.2				
Phoma sp.	0.22	4.2	0.28	6.3		
Rhizopus Ehrenberg	0.12	10.4	0.50	20.8		
R. oryzae Went & Prinsen-Geerligs	0.08	6.3	0.23	16		
Rhizopus sp.	0.04	4.2	0.27	4.2		
Scopulariopsis Bainier	0.83	10.4	0.29	22.9	5.26	34.4
S. brevicaulis (Saccardo) Bainier	0.31	6.3	0.07	10.4	0.25	7.3
S. brumptii Salvanet- Duval			0.19	10.4	3.79	29.2
S. candida (Gueguen) Vuillemin					0.02	3.1
S. carbonaria Morton & Smith					0.02	2.1
S. halophilica Tubaki					1.10	22.9
S. spherospora Zach					0.08	4.2
Scopulariopsis sp.	0.52	4.2	0.02	4.2		
Scytalidium lignicola Pesante					0.52	8.3
Setosphaeria Leonard & Suggs	0.49	18.8	0.31	14.6		
S. holmii (Luttr.) K.J. Leonard & Suggs	0.14	4.2				
S. rostrata Leonard	0.27	20.8	0.13	10.4		
Setosphaeria sp.	0.08	4.2	0.18	6.3		
Stachybotrys Corda	6.74	80.2	1.85	42.7	12.25	3.1
S. chartarum (Ehrenberg) Hughes	6.69	80.2	1.85	42.7	12.25	3.1
S. kampalensis Hansf.	0.05	4.2				
Sterile mycelia	0.72	12.5				
Syncephalastrum sp.	0.06	2.1				
Talaromyces sp.	0.03	4.2				
Thermoascus aurantiacus Miehe					0.02	2.1
Torula sp	0.06	6.3				
Trichoderma sp.	0.09	9.4				
Ulocladium Preuss						
U. botrytis Preuss	0.06	2.1				
U. consortiale (Thümen) Simmons	0.06	2.1			0.07	3.1
Yeasts	0.35	2.1				
Total counts	1282733		1079233		24486	
No. of genera (31)	26		18		16	
No. of species (84+3 varieties)	60+2		49+2		41+1	

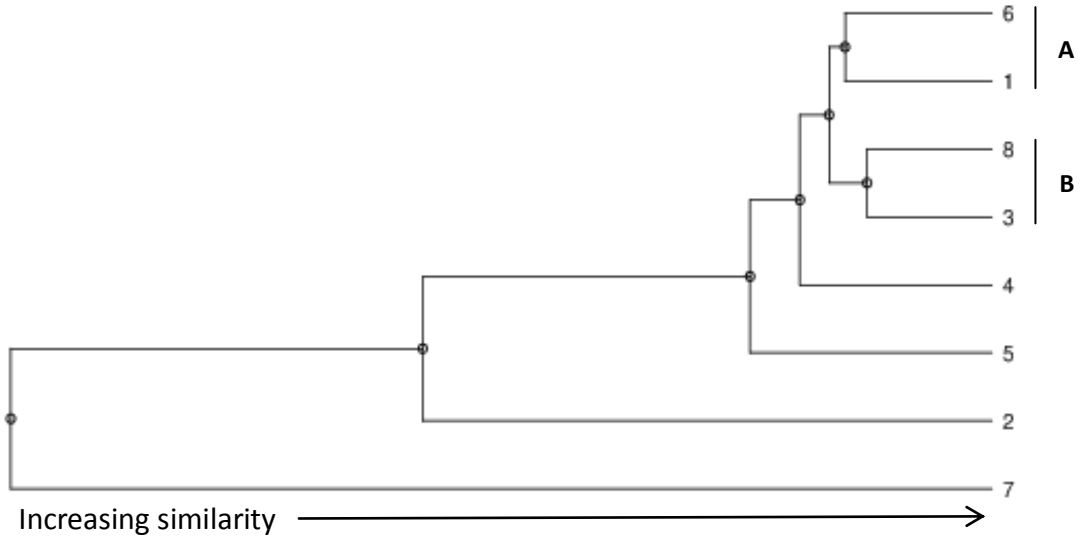

Figure 1. Cluster analysis of 8 lakes; Al Gaar (1), Khadra (2), Al Beida (3), El Zugm (4), Hamra (5), Rosetta (6), Umm Risha (7) and Fasida (8), based on the similarity of their fungal species diversity isolated on Czapek's dox agar medium at 25ºC.

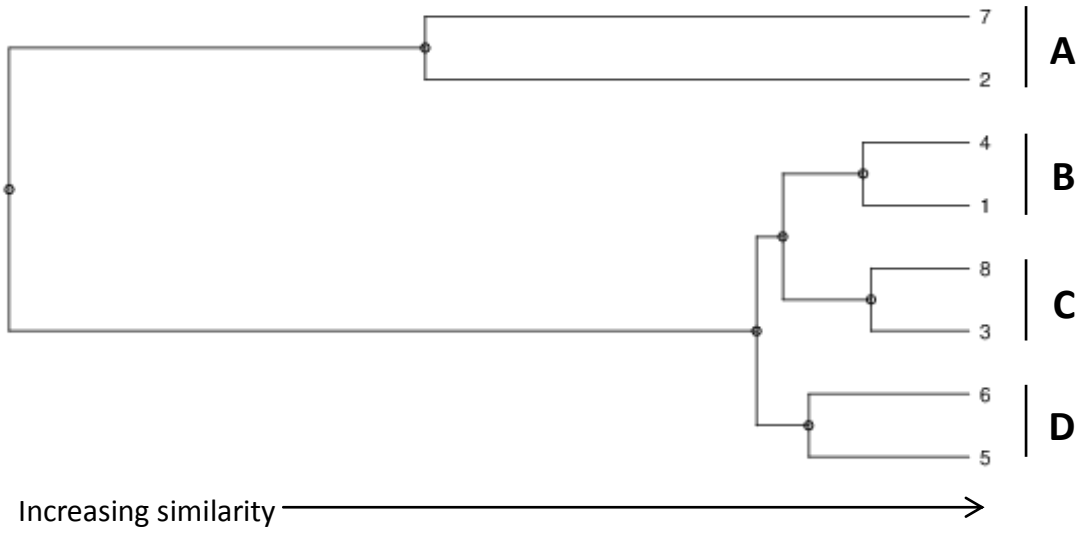

Figure 2: Cluster analysis of 8 lakes; Al Gaar (1), Khadra (2), Al Beida (3), El Zugm (4), Hamra (5), Rosetta (6), Umm Risha (7) and Fasida (8), based on the similarity of their fungal species diversity isolated on Czapek's 40% sucrose agar medium at 25ºC.

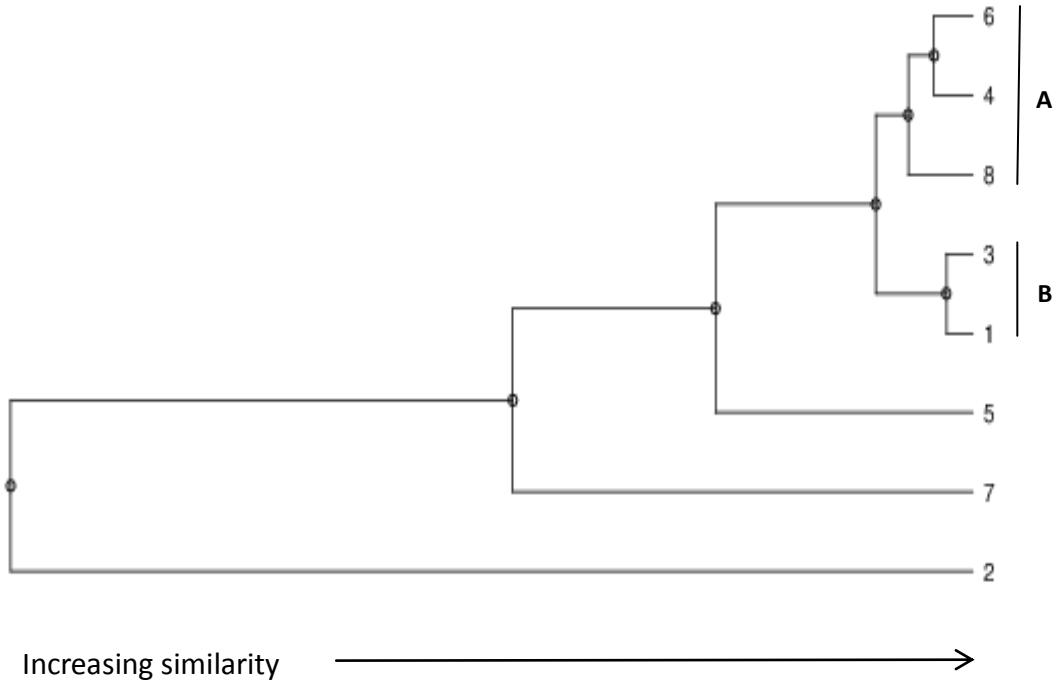

Figure 3: Cluster analysis of 8 lakes; Al Gaar (1), Khadra (2), Al Beida (3), El Zugm (4), Hamra (5), Rosetta (6), Umm Risha (7) and Fasida (8), based on the similarity of their fungal species diversity isolated on Czapek's 10% NaCl agar medium at 25ºC.

Conclusion: In the present investigation a total of 104 species and 3 varieties were collected from soil around 8 lakes of Wadi El- Natrun, from which 60 species and 2 varieties; 49 species and 2 varieties; 41 species and 1 variety were isolated on Czapek´s, 40% sucrose and 10% NaCl agar media respectively. These resultes indicate that the majority of soil fungi of Wadi El- Natrun are osmotolerant/osmophilic and halotolerant/halophilic. *Aspergillus*, *Fusarium*, *Penicillium*, *Emericella* were the most predominant genera on the three media.

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