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Ecological Studies on Lake Al-Asfar (Al-Hassa, Saudi Arabia) with Special References to the Sediment

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Abstract: Some characteristics of Lake Al-Asfar were studied seasonally from May, 2008 to April, 2009. Analysis of sediment core analysis showed that, the maximum content of Zn (5.2 ppm) and Cu (2.5 ppm) were recorded at 5.0 and 25.0 cm depth, respectively. The highest value of Pb was 9.02 ppm at 1.0 cm depth. Eight fungal species belonging to 4 genera were collected from the sediment of Lake Al-Asfar. *Penicillium oxalicum* was the most common fungus recovered from all sections of the core up. *Pythium* sp. was the present at the upper section of the sediment. Marked seasonal quantitative and qualitative differences occurred in the phytoplankton communities of the lake. Five algal groups (Chlorophyceae, Cyanophyceae, Chrysophyceae, Bacillariophyceae and Euglenophyceae) were recorded during the investigation. The maximum seasonal succession was found in the spring, whereas the lowest value was occurred in the fall. The total crop densities were mainly a reflection of the trends in numbers of Chlorophyceae. *Chlorella* sp., *Chlorococcus humicola*, *Oedigonium* sp., *Scenedsemus bijuga*, *Cycltella meneghiniana*, *Cyclotella ocellata*, *Fragillaria capucina*, *Gyrosigma* sp., *Navicula lanceolata*, *Synedra acus* and *Rhadomonas ovalis*.

Key words: Lake Al-Asfar, phytoplankton, sediment fungi, water

INTRODUCTION

Water chemistry exhibit variable physical and chemical characteristics and consequently variable biological compositions. These variations depend mainly on the type and nature of the water area itself as well as on the manmade additions or runoff of minerals and chemicals from agriculture soils (Fathi and Flower, 2005). It is known that, the environmental variables such as physical and Chemical factors affect aquatic life, either saline or brackish water, lead to the appearance of special types of biota (Fathi and Kobbia, 2000; Fathi *et al*., 2001; Fathi and Flower, 2005; Al-Kahtani *et al*., 2007).

Wetlands are areas on which water covers the soil or if water is present either at or near the surface of that soil. A wetland may be found in: shallow lakes: areas of permanent or semi-permanent water with little flow (e.g., ponds, salt lakes, volcanic crater lakes). Wetland ecosystems are sensitive to any disturbance and they not only support biological diversity but also provide because of direct and indirect economic benefits (Flower, 2001).

Lake Al-Asfar represents of those important shallow wetland lakes. However, much of their limnology and its biotic information are still unknown. Few studies were conducted on lake Al-Asfar. The vegetation communities (Youssef *et al*., 2009) and sedimentological, hydrogeological, chemical structure (Al-Dakheel *et al*., 2009) of lake Al-Asfar were studied. Recently, Fathi *et al*. (2009) studied the water quality and phytoplankton communities in lake Al-Asfar, over a period of one-year (March, 2007 to February, 2008). The area is characterized by widespread growth of halophyte shrubs associated with a very thin salt crust on the sabkha surface (The lake is the site of the confluence of

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migratory birds from outside the area visited by dozens of the virtues of birds (Fathi *et al.*, 2009). This study was designed to investigate the presence of pollutants (heavy metals) in the lake using sediment records as well as fungal spores to assess biological patterns. Physical water characteristics and phytoplankton were also measured.

MATERIALS AND METHODS

Site Description

Lake Al-Asfar is one of the important shallow wetland lakes. It is located on Al-Hassa, Eastern region of Saudi Arabia. Al-Hassa Province is one of the largest oases in the world and located (25° 05' and 25° 40') in the Southern part of the Eastern region of Saudi Arabia. The main salient morphologic features of Lake Al-Asfar are wetlands, sabkhas and sand dunes. There are salt tolerant vegetation (halophyte) found in some of the less salt affected sabkha areas.

Sampling and Analysis

Samples were collected from lake Al-Asfar from May, 2008 to April, 2009. Subsurface water samples (2 L) were taken from the lake on each visit. A liter was not filtered and is used for pH, conductivity, alkalinity and chlorophyll. Other liter one was filtered through a Whatman GF C^{-1} filter apparatus equipped with suction pump for analysis. This sample was used for analysis of the major ions for which preservation is not essential. After tightly capping, samples were returned to laboratory and kept in the dark at 4°C until analysis.

Sediment Studies

The sediment samples were taken from the uppermost 1 cm sediment collected during the April, 2008 by a spade box core device (GKG). One sediment core was retrieved from the lake using a technique of Berglund and Ralska-Jasiewiczsowa (1986). The core was sectioned as 2 cm interval and each 2 cm section sample was placed in a Whirlpak bag for temporary storage in a cold at 4°C. Sub-sampling for fungal spore occurrence was taken place during initial core sectioning avoiding contamination.

After dissolution of sediment samples, the metal concentrations were measured by a Varian Atomic Absorption Spectrophotometer (AA-6800F, Shimadzu, Japan).

Sediment core was dissected and side surfaces placed under aseptic conditions in sterilized plastic bags. Fungal spores were isolated by the dilution plate method as described by Abdel-Hafez *et al.* (1990). Glucose-Czapek's agar medium supplemented by chloromphinicol (0.5 mg L^{-1}) and rose bengal (30 µg L^{-1}) and incubated at 28°C for 7 days. Five replications were performed for each sample and the developing fungi were identified and counted and the numbers were calculated per gram dry soil. *Pythium* sp., which were expected to be in the sediment were isolated using VP3 (Ali-Shtayeh *et al.*, 1986) selective medium: sucrose 20 g L^{-1}, corn meal agar 17 g L^{-1}, agar 23 g L^{-1}, $CaCl_2$ 0.01 g L^{-1}, $MgSO_4.7H_2O$ 0.01 g L^{-1}, $ZnCl_2$ 0.001 g L^{-1}, micro-elements: $CuSO_4.5H_2O$ 0.02 mg L^{-1}, MoO_3 0.02 mg L^{-1}, $MnCl_2$ 0.02 mg L^{-1}, $FeSO_4.7H_2O$ 0.02 mg 1 L^{-1}, antibiotics: pimarcin, 5 mg L^{-1}, vancomycin, 75 mg L^{-1}, penicillin, 50 mg L^{-1}, pentachloronitrobenzene, 130 mg L^{-1} and thiamine-HCl 100 µg L^{-1}. Soil from the sediment soil was putted on VP3 media and fungi isolated identified using the Key of *Pythium* species (Plaates-Niterink and Van-der, 1981) and others (Abdelzaher, 1999). Hyphal tips of colonies appeared in VP3 medium were transferred to Water Agar (WA) 2.5-3% and incubated at 20°C to obtain a colony c. 1 cm diameter. The agar medium was inverted and incubated until the colony reached the edge of Petri dish. Slivers of agar containing single hyphal tips were removed from the margin of the colony and transferred to Corn Meal Agar (CMA) (Plaats-Niterink and Van-der, 1981) slants for storage. Hyphal tips were also transferred to

CMA+500 µg mL^{-1} wheat germ oil to stimulate the formation of sexual structures. Pieces from 7-day-old colonies incubated at 25°C were transferred to Nutrient Broth (NB) to confirm the absence of bacteria. The developing fungi were identified according to (Booth, 1977; Domsch and Gams, 1972; Domsch *et al*., 1980; Raper and Fennell, 1965; Samson *et al*., 2004).

Physico-Chemical Characteristics

Temperature and pH values of lake water were measured in the field by a digital pH-meter (Lutron, pH 204), respectively. The Secchi disc depth was measured also in the filed. Conductivity was measured using calibrated conductivity meter (CM 25 conductivity meter). Dissolved oxygen was measured according to Winkler method (Strickland and Parsons, 1972). The calculated values are the mean of triplicates; the standard deviation was less than 5% of these mean values. Chlorophyll-a content of water was determined according to the method described by Strickland and Parsons (1972).

Qualitative and Quantitative Analysis of Phytoplankton Composition

The technique developed by Uttermohl (1936) was adopted for quantitative investigation of the phytoplankton. One and half liter water sample was collected in a cylinder on each sampling occasion and treated with Lugols iodine solution (Iodine in potassium iodide). Each sample was then allowed to settle at least 36 h, where upon the supernatant was siphoned off and the volume was adjusted to 100 mL and kept at 4°C until analysis. Besides, Sedjwick-Rafter cell was repeatedly used for cell counting. The simplified methods described by Willen (1976) and Hobro and Willen (1977) were followed for counting phytoplankton. The average numbers of phytoplankton (unicellular, colonial and filamentous) were performed for every species. The results were then, expressed as number of cells per liter. Qualitative analysis was carried out using the preserved as well as fresh samples. These were examined microscopically for the identification of the present genera and species. Diatoms frustules with and without chloroplast was included. The algal taxa were identified according to standard references, including Smith (1950), Fott (1972), Bourrelly (1981) and Prescott (1987). The calculated values are the mean of triplicates; the standard deviation was less than 5% of these mean values.

RESULTS AND DISCUSSION

The biotic variables used to describe different freshwater areas are often related to environmental factors such as climate, chemistry and pollution. A consideration of these factors leads to a better understanding the biology of aquatic habitats. The present study was carried out in a shallow Lake Al-Asfar.

The results of heavy metals from Lake Al-Asfar are shown in Fig. 1. The data revealed that the maximum content of Zn (5.2 ppm) and Cu (2.5 ppm) were recorded at 5.0 and 25.0 cm depth, respectively. The highest value of Pb was 9.02 ppm at 1.0 cm depth. Establishment of metal levels in sediments could play an important role in detecting sources of pollution in aquatic systems (El-Sammak and El-Sabrouti, 1995; Peters *et al*., 2001; Fathi and Abdelzahar, 2003). Accordingly, the highest value of Pb in the sediment at 0.5 cm depth is a clear indicator of lake pollution in agreement with Fathi *et al*. (2001). Shakweer *et al*. (1993) reported that Cu and Zn concentration in the fish flesh were found to be lower than the levels allowable for the human consumption. However, values of Pb were higher than the tolerable concentration for man. This pollution could was thought to be associated with the input from different drains (Fathi and Abdelzahar, 2003).

Eight fungal species belonging to 4 genera were collected from the sediment soil of Lake Al-Asfar. *Penicillium oxalicum* Currie and Thom was the most common fungus recovered from all sections of the core up to the 10 cm deep section of the core (Table 1). *Penicillium oxalicum* could be tolerating anoxic condition. *Pythium* sp., was present in the most upper section of the sediment and disappeared

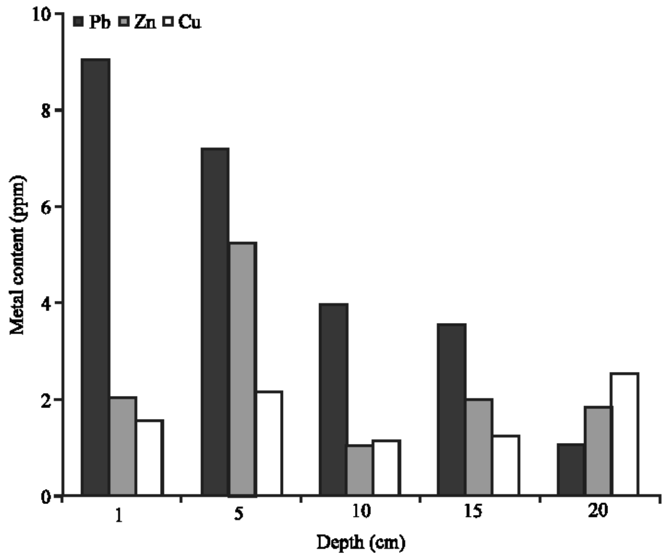

Fig. 1: Heavy metals stratigraphy from Lake Al-Asfar sediment

Table 1: Fungi presented in Al-Asfar Lake sediment

Sediment position (cm)	Fungal species
0-2	*Aspergillus niger*
	Penicilliumoxalicum
	Trichodermakoningii
	Trichoderma sp.
	Pythiumcatenulatum
	Pythium flevoense
	Pythium papillatum
	Pythium group F
	Pythium group P
2-4	*Aspergillus niger*
	Penicilliumoxalicum
	Trichodermakoningii
	Trichoderma sp.
4-6	*Aspergillus niger*
	Penicilliumoxalicum
6-8	*Penicilliumoxalicum*
8-10	*Penicilliumoxalicum*
10-12	Nothing
12- the end of the core	Nothing

thereafter. *Pythium catenulatum* Matthews, *P. flevoense* Van der Plaats-Niterink, *P. papillatum* Matthews, *Pythium* group F and *Pythium* group P were found to be occurred only in the upper 2 cm of the sediment. This indicates that *Pythium* sp., could not to be tolerate the absence of oxygen. *Trichoderma koningii* Oudem and *Trichoderma* sp., were only found in the upper 4 cm of the sediment. In Japan, many isolates of *Trichoderma* sp. were isolated from the sediment of Sagami Bay of Off-Izu Islands (Imada *et al*., 2001; Fathi and Abdelzahar, 2003). This result was the harmony with the present study which indicated that *Trichoderma* sp., prefers that condition. *Aspergillus niger* Van Tieghem was detected up to 6 cm deep while *Penicillium oxalicum* was detected up to 10 cm depth and no fungi were found after that. Noteworthy that no active fungal spores were detected below 10 cm sediment depth (Table 1).

The average water temperature of Lake Al-Asfar was subjected to seasonal variations. The lowest values were recorded during winter (12.5°C), while the highest value was found at the summer

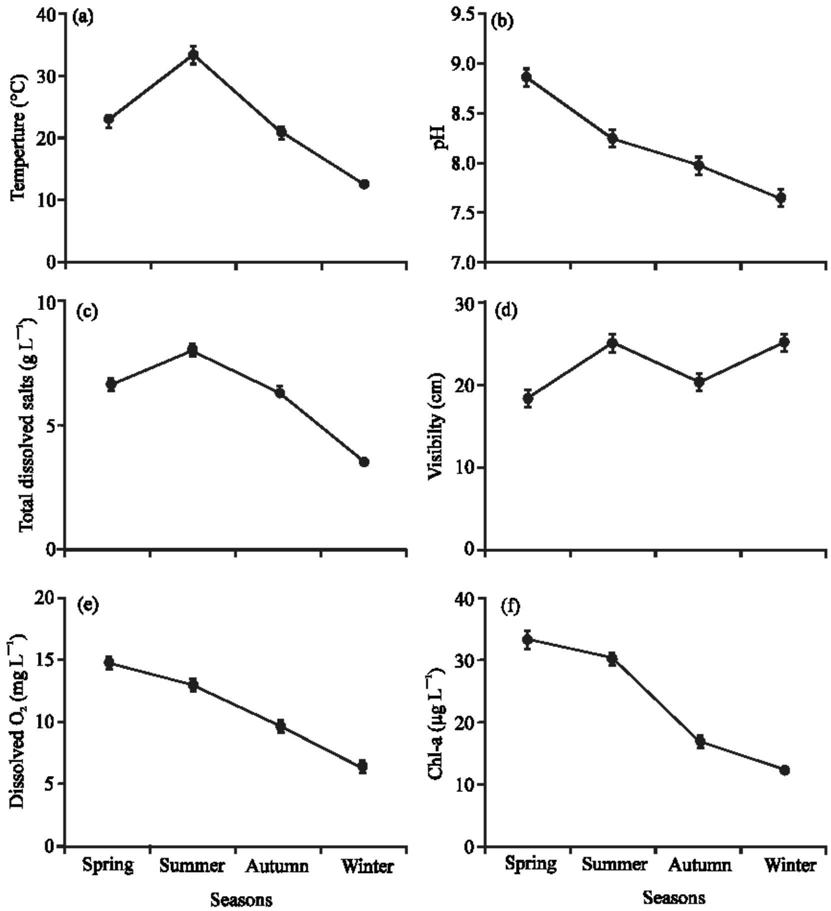

Fig. 2: Seasonal variations of (a) temperature, (b) pH, (c) total dissolved salts, (d) visibility, (e) oxygen content and (f) Chl-a content in Lake Al-Asfar during the investigation period. Vertical bars indicate SE, n = 3

(33.2°C). The differences in temperature represent one of the main factors responsible for the differences in the phytoplankton quantity and quality (Fathi and Flower, 2005; Fathi *et al.*, 2009). Like all inland waters (Flower, 2001) the pH values of Lake Al-Asfar ranged between 7.65 and 8.86 at winter spring and spring, respectively. The lowest values of pH recorded in the Al-Asfar lake may be due to the great amount of agricultural water discharged into the lake (Fig. 2), as well as, to the decomposition of plankton and organic matter (Gharib and Soliman, 1998; Fathi *et al.*, 2009). Figure 2 showed that the total dissolved salts in the Lake water was higher in summer (8.02 g L^{-1}), whereas it dropped to a minimum level in winter (3.32 g L^{-1}). The lake water showed low transparency in summer (18 cm) and the highest in winter (25.0 cm) (Fig. 2a-f). Water transparency was greatly affected by phytoplankton and zooplankton blooms (Gharib and Soliman, 1998; Fathi and Flower, 2005) and disturbance (circulation) of the sediment by wind. Dissolved oxygen is an important variable for identification of different water masses (Fathi *et al.*, 2001). Various aquatic animals including fishes require high levels of oxygen. Figure 2 showed that the maximum oxygen concentration (15.21 mg L^{-1}) was recorded in spring, while the minimum (5.29 mg L^{-1}) was recorded in the winter (Fig. 2). The relatively high concentrations of dissolved oxygen recorded in this study could be due to

Table 2: Relative occurrence of the phytoplankton on Lake Al-Asfar during the study period

Algal taxa	Spring	Summer	Autumn	Winter
Chlorophyceae				
Actinastrum hantzschii Lagerh.	1	1		
Actinastrum sp.	1	2	2	
Chlorella sp.	4	4	3	2
Ankistrodesmus fusiformis Corda	2	2		1
Chlorococcus humicola (Nag)	4	3	2	1
Crucigenia sp.			1	1
Gleocystis major Gerneck			1	1
Monoraphidium contortum Komarava	2	3	3	2
Oedogonium sp.	4	4	3	2
Pandorina sp.	1	1	1	
S. acuminatus Chodat			1	
S. bijuga (Turp.) Lag.				1
S. quadriquda (Breb).	1	2		
Schroederia setigera Lemm.	1	1		
Tetraedron muticum Hansgirg	1			
Bacillariophyceae				
Amphora ovalis Kutz		1		
Cocconies sp.	2	2	1	1
Cyclotella meneghiniana	4	4	3	2
Cyclotella ocellata	1			
Cymbella cistula	1		1	1
Diatoma sp.	1	1		
Fragilaria capucina	3	2	2	
Gyrosigma sp.	4	4	3	1
Navicula lanceolata	3	3	1	1
Melosira granulata	1			
Navicula sp.	1	3		
Nitzschia sp.	2	2	2	1
Stephanodiscus invisitatus	1	1		
Surirella obonga	3	3	2	
Synedra acus Kutz	3	3	1	
Synedra ulna	1		1	
*Tabellar*ia sp.	2	2	1	
Cyanophyceae				
Anabaena sp.	1	1	1	
Chroococcus turgidus Nagel	2	2	1	
Gloeocapsa sp.	1			
Lyngbya sp.	2	2		
Microcystis aeruginosa (Kleb.) Geitler	1			
Oscillatoria sp.	3	3		
Phormidium sp.	1		1	
Euglenophyceae				
Euglena acus Ehrenberg	1			
Euglena promixa Dangeard	2	3		
Phacus sp.	1	2		
Chrysophyceae				
Rhadomonas ovalis Nygaard	3	3	2	1

(High = 4; Moderate = 3; Frequent = 2; Rare = 1)

the increased photosynthetic activity of phytoplankton populations. In this respect, Talling (1976) stated that oxygen super saturation due to photosynthetic activity is often encountered in regions with abundant phytoplankton. On the other hand Chlorophyll-a content in spring exceeded that recorded in other samples (Fig. 2), which could be attributed to vigorous phytoplankton growth (Fathi and Kobbia, 2000; Fathi and Abdelzahar, 2003).

It is evident from the data in Table 2 and Fig. 3-5 that there are is a seasonal differences in quantitative and qualitative composition of the phytoplankton. According to phytoplankton abundance the data of Fig. 4 shows that the highest count was found to be in spring (21.30×10^5 cell L^{-1}), followed by summer (18.40×10^5 cell L^{-1}) and the lowest crop was harvested in

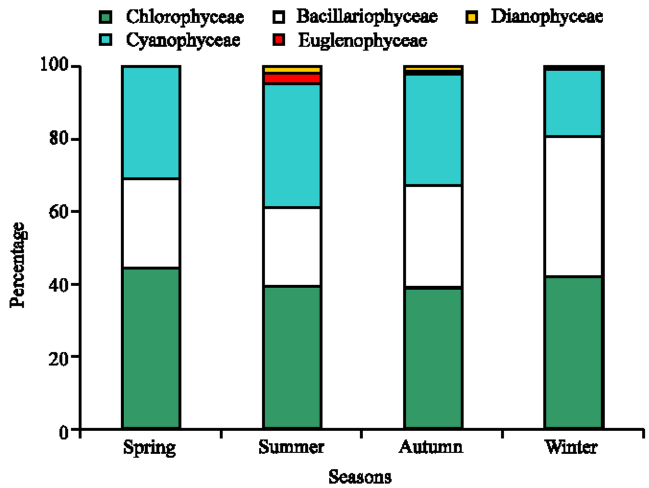

Fig. 3: Percentage composition of the main algal groups recorded at Lake Al-Asfar during the investigation period

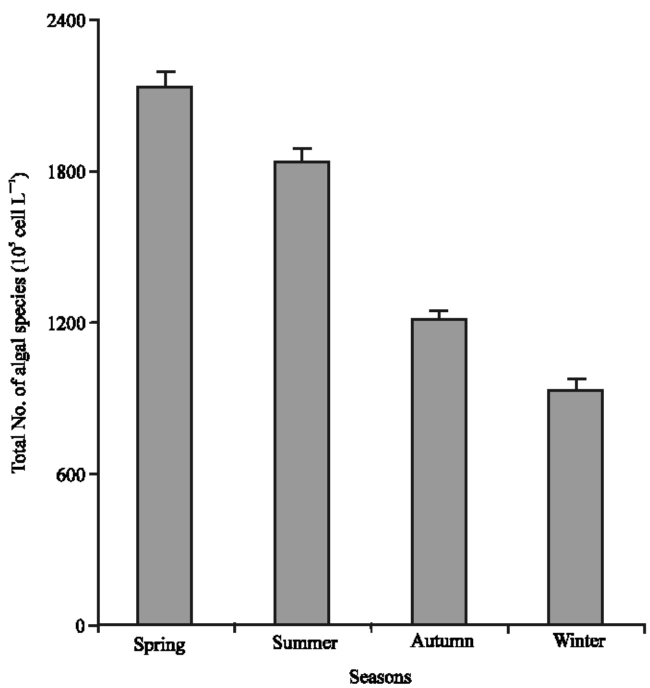

Fig. 4: Phytoplankton abundance for Lake Al-Asfar during the investigation period. Vertical bars indicate SE, n = 3

autumn (9.40×10^5 cell L^{-1}). It could be clearly seen that Chlorophyceae was the most dominant group, Bacillariophyceae ranked second, Cyanophyceae the third, Euglenophyceae the fourth and Dianophycae come the fifth group in the order of dominance during studied period (Fig. 3). Bacillariophyceae reached maximum in winter (38.32%) which was associated with increased numbers

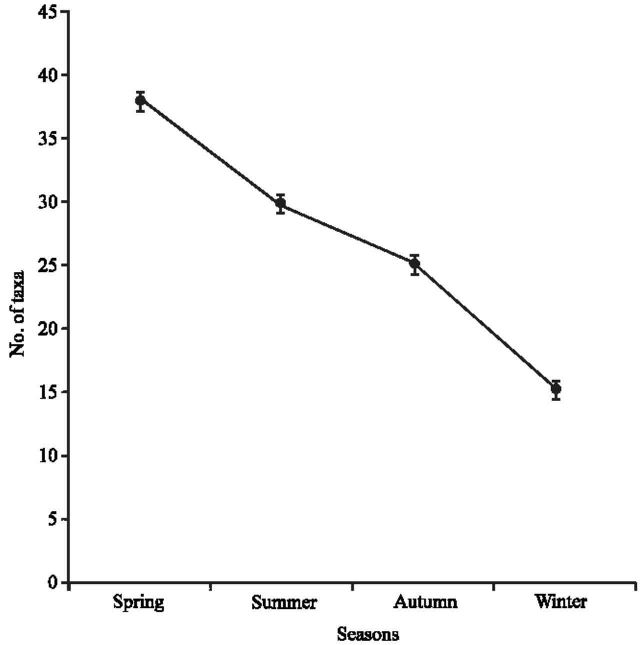

Fig. 5: Seasonal variations of the species richness (total number of phytoplankton taxa encounted per standard sample count) of Lake Al-Asfar phytoplankton, during the investigation period. Vertical bars indicate SE, n = 3

of *Cyclotella meneginiana*, while the minimum (21.21%) was recorded in summer. In contrast, the blue green algae reached its maximum level in the summer (34.22%), while the minimum (18.21%) was found to be in winter. Euglenophyceae was appeared in all seasons except winter. However, Dinophyceae was recorded in summer, autumn and winter (Fig. 3).

Total of forty three genera were mainly identified during the whole period of study (Table 2). Out of these, 15 genera belong to Chlorophyceae, 17 to Bacillariophyceae, 7 to Cyanophyceae, 3 to Euglenophyceae and 1 to Chrysophyceae. On the other hand, the maximum species richness (38 species) was found in the spring, while the minimum (15 species) was in the winter (Fig. 5). Generally, the phytoplankton showed a remarkable increase as compared with the previous records (Fathi *et al*., 2009) and this indicated high level of eutrophication in Lake Sector. Furthermore, Fathi *et al*. (2009) reported that Lake Al-Asfar is indicates heavy polluted in autumn and winter and moderate pollution in spring and summer.

In conclusion, the investigated lake is contaminated with discharge waters containing chemical fertilizers in addition to domestic and industrial effluents. Pollution and climate greatly affected the hydrography and the physico-chemical properties of water as manifested by the high amounts of organic matter, high concentrations of nutrient salts which caused some increase in levels of eutrophication.

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