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Ecological Studies on Al-Khadoud Spring, Al-Hassa, Saudi Arabia

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Abstract: Al-Khadoud spring is one of the most important water resources in Al-Hassa Governorate, Saudi Arabia. However, much of its biotic information is still unknown. This study presented preliminary ecological information of this aquatic body. Regarding to macrophytes, a total of eight species were observed along the study sites. These species include two submerged aquatic plants (*Potamogeton pectinatus* L. and *Ceratophyllum demersum* L.). The common distributed species are *Phragmites australis* (Cav.) Trimex Steud and *Cyperus rotundus* (L.). On the other hand, a total of 20 algal genera were recorded with 7 genera of Chlorophyceae, 8 of Bacillariophyceae, 4 of Cyanophyceae and one of Euglenophyceae. The common phytoplankton occurred in all three investigated sites were *Chlorella vulgaris*, *Mougeotia* sp., *Oscillatoria* sp. and *Actinastrum* sp. Regarding to the biotic fauna, different forms of unicellular zooplankton such as *Paramecium* and *Amoeba* were recorded. Invertebrates such as freshwater insects and some freshwater snails were documented in the study sites including *Melanodies tuberculata*, *Melanopsis praemorsa* and *Lymnaea auricularia*. As regard to vertebrates, one species of fish, *Aphanius dispar*, dominate the spring basin and its extended channels.

Key words: Al-Khadoud spring, macrophytes, phytoplankton, zooplankton

INTRODUCTION

Conservation of biological diversity and the sustainable use of the resources of Earth are enshrined in Islamic law and principles. It is therefore fitting that in 2001 the Kingdom of Saudi Arabia became a signatory to the Convention on Biological Diversity that seeks to ensure the conservation of species and their habitats for all time.

Al-Hassa's Province is one of the largest oases in the world and located in the southern part of the eastern region of Saudi Arabia. An agricultural area of Al-Hassa receives the highest solar energy load 1200 W m^{-2} in the world (Dreaver *et al*., 1981), thus providing favorable arid ecosystems for algae and wild plants to grow. Arid environments are the most diverse ecosystems of Saudi Arabia. However, much of their Limnology and its biotic information are still unknown to the scientific community.

Ecologists have used different analyses to investigate relationships among macrophytes and watershed variables in various parts of the world (Fensham *et al*., 2004). Local and regional studies have also related trophic state to the distribution of macrophytes and their communities (El-Naghy *et al*., 2004; El-Lil, 2006). These kinds of studies are useful in understanding the implications of environmental change for aquatic plants and other biota, while also identifying reliable indicators for monitoring those responses.

Okla (1987) studied the algal microfacies in upper Tuwaiq mountain limestone (Upper Jurassic) near Riyadh, Saudi Arabia. Khoja (1993) described abundant growth of filamentous algal mats (56 m^2) as floating weeds. In Saudi Arabia, recently Al-Homaidan (1994a, b) described planktonic algae and water chemistry of various water bodies. Okla (1987) studied the algal microfacies in upper tuwaiq mountain limestone (Upper Jurassic) near Riyadh, Saudi Arabia. Hussain *et al*. (1996) surveyed (Oct. 1991-Sept. 1992) a 16.5-km-long irrigation canal in Al-Kharj City, for its water chemistry and Charophyte periodicity and density. Al-Homaidan and Arif (1998) studied the seasonal succession of bloom-forming algae over a period of 3 consecutive years (1992-1995) in relation to the trophic changes taking place in a semi-permanent rain-fed pool at Al-Kharj, Saudi Arabia. On the other hand quantitative surveys of the intertidal macrobiota were conducted between 1991 and 1995 in the Saudi Arabian Gulf along permanent transect lines (PTLs) by Jones *et al*. (1998). Baker and Hosny (2005) studied the zooplankton diversity and abundance in Half Moon Bay, Saudi coastal waters, Arabian Gulf. Recently, Al-Fredan and Fathi (2007) investigated the Edaphic algae in Al-Hasa, Eastern region, Saudi Arabia.

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Baker and Hosny (2005) studied the zooplankton diversity and abundance in Half Moon Bay, Saudi coastal waters, Arabian Gulf. Results have shown important seasonal changes in the properties of studied waters characteristics, which then influenced the zooplankton species abundance and richness. Water temperature fluctuated between 16.5 and 35°C, while salinity changed between 56 and 64.5%, Chlorophyll concentration varied between 0.022 and 0.5 μg L^{-1}. Eighty one species of zooplankton belonging to 58 genera have been identified. Copepods dominated zooplankton communities with 42 species constituting more than 51% of the total diversity. Very poor values of abundance have been recorded for zooplankton in the study area not exceeding 366 individuals m^{-3} and in most cases, it was less than 50 individual m^{-3}. Copepods constituted more than 70% of this freshwater organism diversity of invertebrates. Zooplankton biomass ranged between 0.15 and 10.8 mg m^{-3} dry weight. Parameters have been correlated statistically.

It is well known that biotic variables are used to describe water recourse areas and water quality. Al-Khadoud spring is one of the most important water resources in Al-Hassa, however; much of its biotic information is still unknown. The present study may represent the first attempt to survey the biota inhibiting Al-Khadoud's spring and its irrigational channels. This study should present preliminary ecological information of this aquatic body of freshwater.

MATERIALS AND METHODS

Site description: Al-Hasa lies in the south of the Kingdom's Eastern region and is bounded by the Al-Dahna and the Al-Daman deserts. It is situated between 25° 05' and 25° 40' northern latitude and 49° 55' eastern longitude. The Al-Hasa oasis is the largest oasis in the Kingdom of Saudi Arabia and the municipality of Al-Hasa constitutes the largest administrative area in the Kingdom. Al-Hassa has a dry, tropical climate, with a five month summer and a relatively cold winter. It enjoys the benefit of copious reserves of underground water which has allowed the area to develop its agricultural potential. Al-Hassa's water mainly originates from an underground source through a number of artesian springs. The water from these free-flowing springs has been used to irrigate about 20,000 ha of arable land for centuries. Al-Khadoud's spring is one of the most important water resources in Al-Hassa Region and plays an important role in agricultural activities in the area. It is located nearly 5.0 km Northwest of King Faisal University main campus.

Sampling: Three subsurface water samples were taken from the Al-Khadoud spring and its irrigational channel. The surface water samples were collected only once during April, 2006 from three sites. Site 1 (The water basin of Al-Khadoud spring), site 2 and site 3 (Al-Khadoud main irrigational channel) which were located 3 and 5 km north of Al-Khadoud spring basin, respectively. Samples of freshwater invertebrates (ex., snails and freshwater insects) and fish were collected from the study sites for identification. At the same time samples of the aquatic vegetation were assembled at different transects covering the sampling sites.

Physico-chemical characteristics: Water temperature, pH and transparency were measured in situ. pH was measured using a pH meter (370 pH meter Jenway, UK). Transparency was measured using a secchi disc of 20 cm diameter, conductivity using a calibrated Conductivity Meter (470 Conductivity meter, Jenway, UK). Determination of chloride and total alkalinity are given in methods of Water and Waste Water Examination (Adams, 1991). The calculated values are the mean of three replicates; the standard deviation was less than 5% of the mean value.

Macrophyte: For the purpose of this study, some plants could not identified in the field using standard floras therefore samples were collected and preserved for future identification. The identification of plant specimens requires a considerable amount of time and effort. The identification of unknown plant material is accomplished with the use of dichotomous keys; published plant descriptions, illustrations and photographs (Tackhlom, 1974; Migahid, 1978; Chaudhary and Cope, 1983; Collenette, 1985, 1998, 1999; Cope, 1985, 1986; Chaudhary, 1989; Miller and Cope, 1996).

Quantitative and qualitative analysis of phytoplankton: For plankton analysis, 1.5 L^{-1} water samples were fixed in the filed with acid Lugol's solution (1 ml L^{-1} sample). Samples were then allowed to settle for at least 36 h, where after the supernatant was siphoned off and the remaining volume was adjusted to 100 mL. This 100 mL sample was kept at 4°C until analysis. Phytoplankton counts were done using a Wild inverted microscope following the Utermöhl technique (Utermhl, 1958). For counting, the simplified methods described by Willén (1976) and Hobro and Willen (1977) was followed. The counts of phytoplanktonic algae (unicellular, colonial or filamentous) were expressed as cells mL^{-1}. The algal taxa were identified according to standard references, including Smith (1950), Fott (1972), Bourrelly (1981) and

Prescott (1987). The appropriate statistic in Brillouin's index (Pilou, 1966) was used for quantitative analysis of species diversity of the phytoplankton.

Fauna of AL-Khadoud spring: Zooplankton samples were collected on each occasion with a net mesh size of 80-100 μm and preserved in isopropyl alcohol. Zooplankton species were identified according to Fenaux (1967) Tregouboff and Rose (1978). Samples of invertebrates (snails) and vertebrates (frogs and fish) were collected on the same time and brought into the lab for further identification. The classification of some invertebrates can be tedious and therefore the dichotomous keys were used.

RESULTS AND DISCUSSION

The biotic variables used to describe different water 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. Arid environments are the most diverse ecosystems of Saudi Arabia. However, much of their biotic information is still unknown to the scientific community (Al-Homaidan and Arif, 1998).

Water temperature was not significantly different within sites and fluctuated between 30 and 33°C. The pH was always alkaline in all investigated sites. Total soluble salts and conductivity (salinity) were relatively high in all sites. However, the maximum value was record on site 3 (1.21 g L^{-1} and 2.97 μS, respectively). The transparency of water (Table 1) reached zero on all sites. Regarding to total alkalinity and chloride the maximum value was record on site 3, however no much differences between other two investigated sites.

The distribution of the major identified macrophytes from the different water sources of the study area which includes Al-Akhdad Spring (Site 1), the extended canal (Site 2 and 3). A total of eight species were observed along the study sites (Table 2). These species include two submerged aquatic plants (*Potamogeton pectinatus* L. and *Ceratophyllum demersum* L.) which observed frequently in the Spring Site 1 and Site 3. At all studied sites, the common distributed species are *Phragmites australis* (Cav.) Trimex Steud and *Cyperus rotundus* (L.). However, they are important as producers in nutrients rich freshwater habitats and the irrigation and drainage canals (Zahran and Willis, 1992). However, other macrophytic species were recorded in different proportions around the sites under investigation such as *Typha latifolia* L., *Juncus rigidus* (Desf), *Carex divisa* (Huds.) and *Tamarix aphylla* (L.) Karst). Generally, the species occurrence of

Table 1: Some physical and chemicals characteristics of Al-Khadoud's spring and its irrigation channel (April, 2006)

Parameters	Site 1	Sit 2	Sit 3
Temperature (°C)	33.00	30.00	30.00
pH	7.48	7.46	7.90
Transparency (cm)	0.00	0.00	0.00
Conductivity (μS)	2.22	2.35	2.97
Total dissolved salts (g L^{-1})	1.40	1.44	1.81
Total Alkalinity (mg L^{-1})	3.72	3.60	4.30
Inorganic carbon (mg L^{-1})	10.788	9.36	10.99
Chloride (mg L^{-1})	310.000	200.00	410.00

Table 2: Distribution of the major macrophytes species observed in Al-Khadoud's spring and its irrigation channel (April, 2006)

	Occurrence (Distribution)		
Plant species	Site 1	Site 2	Site 3
Potamogeton pectinatus	++	-	-
Ceratophyllum demersum	++	-	+
Phragmites australis	+	+++	++++
Typha latifolia	-	-	+
Cyperus rotundus	-	+	+
Juncus rigidus	-	+	+
Carex divisa	+	-	++
Tamarix aphylla	-	+	+

High = ++++; Moderate = +++; Frequent; = ++; Rare = +

the various macrophytes of the study varies greatly being highest around Site 3 which was dominated by *Phragmites australis*.

Habitat quality is influenced by the ratio of emergent macrophyte cover to open water (Salvador *et al*., 2004). Aquatic species are occurred in water and wetlands of different phytogeographical regions. They can form deep roots and hollow rhizomes that remove organics and suspended solids as well as nitrogen, phosphorus from wastewater (Zahran and Willis, 1992; Wells *et al*., 2003). Local and regional studies have also related trophic state to the distribution of macrophytes and their communities (Fathi and Abdelzahaher, 2003; El-Lil, 2006). These kinds of studies are useful in understanding the Implications of environmental change for aquatic plants and other biota, while also identifying reliable indicators for monitoring those responses.

It is well known that, the changes in physico-chemical characteristics of any water mass lead to concomitant qualitative and quantitative changes in phytoplanktonic organisms (Ahmed *et al*., 1986). There are marked differences in the quantitative and qualitative composition of the phytoplankton communities at each site. In terms of phytoplankton abundance (Table 3), the highest maximum counts (23.9×10^5 cells L^{-1}) were recorded in site 3, whereas the lowest crop densities (15.11×10^5 cells L^{-1}) occurred in site 1 (spring water basin).

Four algal groups were recorded throughout this investigation; namely the Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae. The

Table 3: Species richness (total number of phytoplankton taxa encounted per standard sample count) and phytoplankton abundance (cell No. $\times 10^5$ L^{-1}) in Al-Khadoud's spring and its irrigation channel (April, 2006)

Parameters	Site 1	Site 3	Site 3
Species richness	8.00	19.00	18.0
Phytoplankton abundance	15.11	22.37	23.9

Table 4: The percentage composition of the main algal groups recorded in the phytoplankton of Al-Khadoud's spring and its irrigation channel (April, 2006)

	Composition (%)		
Algal groups	Site 1	Site 2	Site 3
Chlorophyceae	63.67	54.86	52.05
Bacillariophyceae	21.31	27.94	27.78
Cyanophyceae	9.40	10.34	13.22
Euglenophyceae	5.62	6.86	6.95

Table 5: Relative occurrence of the phytoplankton on Al-Khadoud's spring and its irrigation channel (April, 2006)

Algal group	Site 1	Site 2	Site 3
Bacillariophyceae			
Cyclotella meneghiniana Kützing		+	+
Fragilaria capucina Desmaziéres		++	+++
Navicula sp.		+	
Nitzschia closterium Ehernberg		+	++
Surirella ovalis Breb	+	+	+
Synedra acus Kützing	+	+	
Tabellaria sp.		+	+
Chlorophyceae			
Actinastrum sp.	+	++	++
Ankistrodesmus falcatus (Corda) Ralfs		+	++
Carteria multifilis Fres.		+	+
Chlamydomonas sp.	+	+	+
Chlorella vulgaris Beyerinck	++	++	++
Eudorina sp.		+	+
Scenedesmus quadriquda (Turp.) Bréb.	+	++	++
Mougetia sp.	++++	++	+
Cyanophyceae			
Chroococcus turgidus (Kütz.) Näg		++	++
Cylindrospermum sp.			+
Merismopedia elegans Braum		+	+
Oscillatoria sp.	++	+++	++
Euglenophyceae			
Euglena acus ehrenberg.		+	+
Diversity index (H)	3.89	3.17	2.02

High = ++++; Moderate = +++; Frequent = ++; Rare = +

total percentage composition, which illustrates the relation between the four main phytoplankton groups (Table 4), shows that Chlorophyceae were the most dominant group in Al-Khadoud spring. Bacillariophyceae ranked second, Cyanophyceae ranked third and Euglenophyta ranked the fourth. A total of 20 genera were recorded with 7 genera of Chlorophyceae, 8 of Bacillariophyceae, 4 of Cyanophyceae and one of Euglenophyceae. The maximum number of genera (19) appeared in Site 2 and the minimum (8) in Site 1 (spring basin). The common phytoplankton occurred in all three investigated sites were *Chlorella vulgaris*, *Mougeotia* sp., *Oscillatoria* sp. and *Actinastrum* sp.

The maximum diversity index (3.89) was estimated on site 1, while the minimum (2.02) was in site 3 (Table 5). It should be noted that biological indices of species diversity, based mainly on the composition of phytoplankton have been proposed by Pilou (1966) and Nygaard (1978) may indicate the pollutional state of water. There are several numerical attempts (Fathi *et al*., 2001; Fathi and Flower, 2005) to express degrees of oligotrophy and eutrophy from a consideration of species complements rather than from nutrient levels. Some workers (Fathi and Zaki, 1999; Fathi *et al*., 2001; Fathi and Abdelzahaher, 2003; Fathi and Flower, 2005) believe that the biological estimation of the degree of eutrophication and pollution of aquatic ecosystems is probably more informative than chemical determinations. According to scales of Staub *et al*. (1970), Site 1 (Spring basin) and site 2 considered a slight pollution area (diversity index: 3.00-4.50), however the site 3 a light pollution area (diversity index: 2.00-3.00).

Regarding to the biotic fauna, different forms of unicellular zooplankton such as *Paramecium* and *Amoeba* were recorded. Invertebrates such as freshwater insects and some freshwater snails were documented in the study sites including *Melanodies tuberculata*, *Melanopsis praemorsa* and *Lymnaea auricularia*. As regards to fish, *Aphanius dispar*, was found to be the main fish species dominate the spring basin and its extended channels.

In general, the biological samples collected from Al-Khadoud spring sites provided a preliminary survey of the abundance and occurrence of species typically found in water springs in Saudi Arabia. Because sampling was restricted to one time, the survey clearly does not represent a detailed comparative study of biological diversity in the region. Accordingly, a biological diversity of Al-Khadoud spring will be complete on future study.

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