Ecophysiological Studies on Seagrass (*Ruppia cirrhosa*) Petagna Grande, in Lake Qaroun, Egypt with Emphasis on Remote Sensing and Rough Set Approach

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**Abstract:** Lake Qaroun is a hydrotrrophic lake. It is considered as the most dynamic and highly changing lake in Egypt during the last two decades. The lake water, sediment and plant analysis were investigated in this study. Reduction for parameters were obtained using rough set data analysis. Field results used to construct a Geographical Information System (GIS) map, the Land Sat- image has provided a very good vision to study the ecophysiological properties of the lake and the intensive distribution of the sea grass *Ruppia cirrhosa*, due to the highest level of salinity, DO, NH₃, NO₃ and NO₂ (43.14 g/l, 6.97mg/l, 455.89, 40.67 and 180.65 μg/l) respectively, which is suitable for the vigorous growth for such seagrass, while, Polysaccharides, protein, crude fiber and total lipids were (1.90, 25.64, 36.24 and 0.82 mg/g dry wt.) respectively.

**Key words:** Lake Qaroun • Environmental changes • *Ruppia cirrhosa*

**INTRODUCTION**

Seagrasses form the most widespread and productive lakes systems in the world [1, 2]. Seagrass meadows stabilize and enrich sediments, support highly productive epiphytic organisms [3] and provide critical food resources and habitat for a variety of water birds and marine organisms [4, 5]. They represent ecosystems of great importance in terms of biodiversity [6, 7]. They are sensitive to human (e.g. aquaculture, pollution, dredging and development [8, 9]) and natural (e.g. earthquakes, disease and storms [10-12]) indicators of water quality and overall health of a lakes ecosystem [13]. They have received less attention i.e. their abundance, distribution, growth pattern and their role in Lake Qaroun ecosystem compared to other locations without covering seagrass batches found that, macrophytes increase with decreasing salinity [14]. Also, it found that *Tilapia zilli* in Lake Qaroun feed on vegetable and animal materials [15-17]. This study aimed to reveal the ecophysiological properties of lake Qaroun, during four successive seasons (spring 2003- winter 2004) based on records at three stations inside the lake in addition to the two main drains (El-Batts and El-Wadi) discharging into the lake and distribution of *R. cirrhosa* inside the lake was observed by using Land Sat images during 2003-2004.

**MATERIALS AND METHODS**

**The Study Area:** Our lake laying in Faiyum Governorate (90 km SSW of Cairo, Egypt). It is located between latitudes 29° 24' and 29° 33'N and longitudes 30° 25' and 30° 50'E (Figure 1). It receives agricultural drainage water and sewage through 2 main drains El-Batts and El-Wadi, in addition to 11 other small drains and 3 pumping stations and few rain falls [18, 19].

**Hydrology:** Water enters the depression through the natural Bahir Yousef channel. Salinity is rising at a rate of 0.5 g/l each year due to the drainage water received by the lake [20]. Seasonal records were kept at 3 stations of lake Qaroun in addition to the 2 main drains (El-Batts and El-Wadi) discharging into the lake, throughout the period from spring 2003 to winter 2004, all stations were identified and oriented by global positioning system (GPS) personal navigator Trex Vista Hex, USA.

**Water Analysis:** Both temperature and pH was determined using digital pH meter (wtw-91). Conductivity was measured by using EC meter (wtw-1F-910). Depth was measured using echo-sound, transparency by Secchi-disc, chlorides by using silver nitrate method. Dissolved oxygen was determined according
to Thompson and Robinson [21]. NH₄, NO₃, NO₂ and heavy metals were measured according to APHA [22] and Allen et al. [23].

**Sediment Analysis:** Mechanical analysis of sediment was carried out by using the hydrometer method. The pH (1:5) and EC were determined using 2 digital pH and EC meters (wtw-91) and (wtw-tf-910), respectively. Organic matter was determined according to Allen et al. [23] as follows. Organic matter (OM %) multiplied by 2 conversion factor (1/1.727) deduced the value of organic carbon (OC %). Total salt content (TSC %) and osmotic potential (OP %) were calculated from the electrical conductivity values according to Allen et al. [23].

**Plant Analysis:** Determination of Na, K and Ca [23], heavy metals were measured using atomic absorption spectrophotometer (Shimadzu -612). [22], carbohydrates [24], protein content, crude fiber and total lipids [23] were carried out.

**Remote Sensing:** The digital data were processed for geometric and radiometric corrections using ERDAS Imagine processing software version 8.7 (uses the ISODATA algorithm). The TM data were classified using unsupervised and supervised classification techniques [25].

**Statistical Analysis:** Reduction of attributes of the data was applied using rough set analysis [26-28]. The results obtained from rough set were tested statistically [29], using SPSS version 9 to obtain (r) values.

**RESULTS**

Satellite data provides quick and useful baseline information on the parameters controlling the movement of (weed growth and distribution). The remote sensing images of Land Sat-TM acquired in 2003 and 2004 have been used for present study showing the distribution of the seagrass meadow in lake Qaroun (Figure 2-5). Seagrasses were present throughout most of the 0-10 m mapped area, although the lower limit of seagrass beds rarely exceeded depths of 7m. Post classification comparison was applied through ERDAS according to the following 2 main steps:

- A classified image was prepared for the years 2003 and 2004.
- The lake cover map of year 2003 was then subtracted from that of year 2004 to produce a change detection map for the study area.

The various thematic layers generated using remote sensing data like ecology, land use and vegetation cover of the lake could be integrated with collateral data in a GIS framework. Analyses of the GIS domain using logical conditions to derive environmental changes inside the lake in order to assess the weeds distribution and situation in an area, a systematic study of these factors is required in a GIS domain. GIS spatial database development various analogue maps, which were in different scales obtained from different organizations, were converted into digital format by using onscreen digitization method in Arc-View 3.2a software according to the following steps:
The Field data indicate that seagrass meadows were predominantly mixed with dominant spieces *R. cirrhosa*. It is impossible to map the distributions of individual species from aerial photographs analyzed using remote-sensing methods, because these various species have a colimetric proximity. Thus, this horizontal distribution must be supplemented with an evaluation of the vertical distribution of these meadows using the transect method.

Properties of waters of Lake Qaroun Table 1. Temperature was found to range from 29.8 to 32.8°C in station 1 and 2 during spring. The highest mean value was 33.3°C in station 3 during summer and the lowest mean value was 17.1°C in station 1 during winter. The water depth of both drains not exceeding 110 cm while it varied greatly inside the lake, ranged from 350 to 720 cm. Most of the lake’s area has a depth ranging.
From 2 to 9 m. The water level of the lake fluctuates between -41 and -45 m below mean sea level. Transparency of both drains showed the lowest average values which varied between 10 and 25 cm. Station 3 recorded the highest mean value of transparency (90 cm). The pH values of the lake water were on the alkaline side and the average values ranged from 6.7 and 8.5 for El-Wadi drain and station 2, respectively. El-Batts and El-Wadi drains attained the lowest mean values of salinity ranging from 2.85 to 6.83 g/l during spring season. Station 3 attained the highest mean values of salinity (43.14, 39.66, 39.80 and 41.43 g/l) during spring, summer, autumn and winter seasons, respectively. Station 1 and 2 were more or less close to station 3. The dissolved oxygen (DO) in both drain waters exhibited the same trend during the four seasons of the year. The lowest (2.5 mg/l) and the highest value (5.5 mg/l) of DO were recorded in El-Batts drain during summer and winter season, respectively. However, the lowest mean value of the DO (mg/l) in the lake (3.12) was recorded in station 3 while the highest one (8.2) was recorded in station 1 during spring and autumn season, respectively. Nitrogenous compounds in lake water of both drains were much higher as compared with lake water for each season and station. NH3 ranged from 1156.34 to 1656.41 µg/l in El-Batts drain during spring and winter, respectively. However station 3 and station 2 recorded the lowest value (170.85) during summer and the highest (912.37) mean value during spring.

However, lake water attained very high mean values especially in winter season for station 1, 2 and 3 compared with El-Batts and El-Wadi drain. The highest and the lowest mean value of Pb were recorded in station 1 (16.28 and 2.34 µg/g) during summer and spring seasons respectively. Copper, iron and Magnesium showed very high concentrations (83.10, 43.11 and 9.31, respectively) at station 3 during winter and autumn seasons. On the other hand drains showed fluctuated levels of these heavy metals according to time of sampling throughout the period of study (Table 2).

Characteristics of Physical and Chemical Properties of Sediment: Table 3 revealed that, station 1 possessed the highest mean values of sand (%30.15 and 28.90 %) during summer and winter season, respectively, while station 3 having the highest mean values of silt (55.25 and 45.78 %) during spring and autumn respectively. On the other hand, El-Batts drain attained the highest mean values of clay (65.65 and 62.60 %) during autumn and winter season, respectively. The pH mean values of sediment extract (1:5) were generally alkaline inside the lake (8.1 to 8.7), while that of each drains ranged between 7.5 and 7.9. The electrical conductivity (EC) of the lake was much higher than both drains (0.43 to 0.83 mmhos/cm). Station 3 attained the maximum mean values throughout the period of study (15.97, 16.80, 18.39 and 18.47 mmhos/cm) during spring, summer, autumn and winter seasons, respectively. The total soluble salts and Osmotic potential of the sediment extract were in parallel with the mean values of EC. Organic matter and organic carbon content of sediment showed the same trend in either drains or lake. Station 3 possessed the highest mean

<table>
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<th>Season</th>
<th>Location</th>
<th>Temp. °C</th>
<th>Depth cm</th>
<th>Trans cm</th>
<th>pH</th>
<th>Salinity g/l</th>
<th>DO mg/l</th>
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Table 1: Seasonal variation of Physico-chemical properties of water samples of Lake Qarun during the period of study (2003-2004)
values of organic matter (3.5, 6.5, 3.7 and 5.9 % and for organic carbon 2.0, 3.7, 2.1 and 3.4 %) during spring, summer, autumn and winter seasons, respectively.

### Chemical Characteristics of *Ruppia cirrohsa*

It was clear from the present data that, station 3 having the highest values of Na, K, Zn, Pb and other metabolites, however station 1 which attained the maximum mean value of Ca (18.9 mg/g dry wt.) during autumn season. Values of direct reducing value (DRV), total reducing value (TRV) and polysaccharides (1.90 mg/g dry wt.) were higher in station 3 nearly the whole seasons, Protein content of *R. cirrohsa* in station 3 attained 25.64 mg/g dry wt.) during spring, while station 1 recorded the highest values of crude fiber 26.19 and total lipids 0.67 (mg/g dry wt.) during autumn. *R. cirrohsa* was absent in both drains throughout the period of study due to lower salinity level of drain waters (Table 4).
DISCUSSION

Seagrass perturbations and distribution may be an important indicator of water quality and overall health of a lakes ecosystem [13]. Seagrass and aquatic plants with their associated flora and detrital material are of the major food chain in the lakes, river and reservoirs. Rough set theory plays an important role in the reduction of knowledge, decision making and others. In this study, there was more than information systems, all systems have the same universe (locations and seasons) and different sets of attributes as shown in Table 1, 2, 3 and 4, r values represents the selected attributes and relationships with growth and distribution of *R. cirrohsa* in the lake. Changes in temperature affect the water chemistry and biological ecosystem. Temperature of drains shows no detectable differences in their average as temperature depends upon air back radiation and latent heat of evaporation [30]. The high Secchi disc values of the lake water are an indicator to the penetration of light to the bottom of the lake to support growth of seagrass. This agrees with the findings of Levy [31]. Turbidity of lake water is commonly regarded to be attributed mainly to the phytoplankton growth than other allochthonous factors [32]. The gradual decrease in pH values towards the eastern part of the lake might be correlated with the increase of pH of water discharged from El-Batts drain [33], the increase in pH values towards the western part could be due to the photosynthetic activity of phytoplankton near surface layer. In this respect [34] reported the same findings. The alkaline water are areas regarded to be more productive than acidic one [35]. In addition the pH value is one of the most important factors affecting ammonia volatilization from sediments which increase with the increasing pH [36]. Salinity of most Egyptian lakes are lower or much lower than sea water except Qaroun lake, which is much higher than sea water of the Mediterranean Sea. Lake levels are continuing to rise at a rate of 0.1 m per year, while salinity rising 0.5 g/l each year. Also, [20] reported that, the lake bottom siting up by an average of 10 mm each year due to receiving agricultural and waste water by, El-Batts and El-Wadi drains which attained the lowest mean values of salinity. Increasing salinity leads to a decrease in the solubility of carbon dioxide in the water (37). It was pointed out that high salinity would have deleterious effects through inhibiting growth and metabolic activities of phytoplankton [38]. In the same time [39, 40] reported an annual increase in salinity of 0.199% from 1979 to 1989, while, Ancon. [19] recorded an annual increase in salinity of 1.72% from 1993 to 1996. Water alkalinity in Qaroun lake has been dominated by HCO₃⁻ rather than CO₃²⁻, with an annual average of 218 mg/l. Therefore, it can be designated as very hard waters and highly productive. The dissolved oxygen serves as indicator of the water quality [41]. DO results indicated increased in DO content which may be attributed to the intensive growth of *R. cirrohsa* and consequently release of O₂ from roots and
rhizomes [42]. DO in both drain waters exhibited the same trend during the four seasons of the year. The decrease in DO of the lake water might be due to its bacterial consumption during the decomposition of the organic matter [43-45]. The decrease in DO may be due to the consumption of a greater part in the oxidation of dissolved organic matter at the bottom layer [46]. In aquatic ecosystems N is an important controlling factor for biota growth [47]. The maximum value of NH$_3$ was recorded in winter for El-Batts drain, while the minimum value was recorded during the summer season. Nitrification is an important biological process because of its influence on sedimental N that can be leached by denitrification that transforms NH$_3$ to NO$_2$ and NO$_3$. Nitrification is mainly achieved by two groups of bacteria, chemoautotrophic and Nitrobacter [48-54]. Nitrite contents showed irregular distribution in the water. Nitrate which is more stable than both nitrite showed a similar trend with NH$_3$ either in drains or lake water i.e. drains attained the maximum mean value and other stations attained the lowest ones, which might be due to that drains receive all water discharging from agricultural, industrial and domestic wastes, containing very high concentrations of suspended matter in addition to decay of seagrass. These results confirm the correlation between nutrient cycle and growth of seagrass. This respect, [55-57] stated that, the drainage water carrying large numbers of sediment bacteria. However, benthic bacterial activity tended to increase with increasing the productivity of seagrass. Nitrate concentrations in water containing batches of Ruppia are higher than poor localities [58]. [54] Confirm the correlation between nutrients and growth of Ruppia. On the other hand, bacteria and seagrass Ruppia are inversely related, because of competition for inorganic nutrients [59]. Changes in the physico-chemical properties of the lake water may be attributed to variations in the N-cycle bacteria [60]. To improve the lake's water quality and increasing fish production, organic matter has to be reduced to its lower levels to prevent blooming of phytoplankton [61, 62]. Analysis of bottom-sediment of the lake indicated that, the sediment texture varied greatly according to the type of sediment i.e. sand or silt or clay. The close connection between the presence of fine sediments and their content of organic matter was previously recorded [63]. The higher organic matter contents in bottom-sediments during summer in station 3 may be due to the death of seagrass after its blooming. Similarly, heterotrophic bacterial populations usually reach maximum numbers in the sediment-water interface [64]. Heavy metals have today a great ecological significance due to their toxicity and cumulative behavior. These elements, contrary to most pollutants, are not biodegradable and undergo a global eco-biological cycle in which water is the main carrying agent [65]. The heavy metals arranged in this order Cu > Fe > Pb > Zn > Mg. Drains showed fluctuated levels of these heavy metals according to time of sampling throughout the period of study which mean that, the eastern region was more polluted than the western one due to human activities and runoff [60]. Seagrass represents about 60 species with less diverse taxonomically than aquatic weeds, algae and macroalgae [66]. The growth of seagrass depends to a large extent upon the decaying plankton system [67]. The importance of plant is providing the cover and food for many aquatic species; all the plant parts are eaten by waterfowl. R. cirrhosa mostly an inland plant found in alkaline lakes. Mineral and metabolic products of R. cirrhosa showed variations in time and stations. R. cirrhosa, was absent in both drains throughout the period of study due to lower salinity level of drain waters. The greatest abundance of R. cirrhosa was recorded in the presence of rich organic matter and alkaline habitats and it is tolerant to soil conductivity up to 2 mhos/cm and pH 7-9.3. With the addition of sediment from the eutrophic lake the growth of R. cirrhosa plants decreased associated with the decrease in P and N. In shallow and deep water levels Fe increased due to impaired root functioning in rich organic sediment with low oxidation reduction potential (ORP) which restricted O$_2$ transport to roots. Ruppia release O$_2$ and the attached microflora represent an important source of organic matter in the Lagoon [40]. On the other hand, it is important to use mapping vegetation by aerial photographs and image processing beside field data. Although this processing combines an impartiality of the analysis with a great speed of execution, it requires the collection of substantial field data which had much more precise results (within 1 cm) than those obtained by image processing (within 1 m), but could only be applied on a small scale. The continuous monitoring for lake development by using satellite images to protect natural resources from depletion and deterioration. It is recommended to study the scenarios of applying conjunctive use of increasing water budget for El-Faiyum Governorate and ground water recourses in order to prevent the increase of water salinity of the lake and to increase in the total cultivated lands, the decreasing desert and increasing water bodies and fish farms.
REFERENCES


