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Full length article

Deviations in the biochemical structure of some macroalgal species and their relation to the environmental conditions in Qarun Lake, Egypt

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ABSTRACT

Variations in the biochemical structure of seven macroalgal species, belonging to different families were investigated along with subsequent analysis of relevant water physico-chemical parameters. Samples were collected from different sites along the Egyptian Qarun Lake during spring of 2017. The relationship between the macroalgal components and ambient water parameters was studied. The results indicated that the macroalgal components differed according to plant species and spatial variations. The green macroalgae species *Ulva fasciata* was recorded at site 5. It was found to have the highest protein (20.66 ± 0.04%), DCP (15.67 ± 0.04%), P/NFE (0.65 ± 0.01%), P/EV 7.65 ± 0.03 mg crude protein/K cal GE and nitrogen contents (3.31 ± 0.01%). However *Cladophora laetevirens* collected from site7, had the highest lipid, ME, EV and K contents (3.64 ± 0.00%, 3.25 ± 0.00%, 3.99 ± 0.00 K cal/g and 0.40 ± 0.0%, respectively). *Mougeotia genuflexa* from site 4, had the highest ash content (53.58 ± 0.08%). *Gracilaria corticata* from site 6, had the highest NFE and OM contents (76.26 ± 0.15 and 89.68 ± 0.04% respectively) and *Enteromorpha intestinalis* collected from site 2 had the highest P/L value (11.71 ± 0.02%). Statistical analysis (CCA) showed that some environmental variables such as temperature, NO_3, pH, COD and transparency had a strong effect on the macroalgal components and were considered as the most important water variables. While others such as DO, SiO_3, NO_2 and PO_4, exhibited a weak correlation. The present study demonstrates differential response of the macroalgal components to the environmental variables. In addition to the importance of these macroalgal species as a balanced artificial fish and animal feeds, particularly *Ulva fasciata*, which have the highest nutritional components.

Introduction

In intensive aquaculture fish, protein feeding is a highly expensive dietary source that represents over 50% of operating costs (Lovell, 2002). So over the past decades, uninterrupted efforts had been made to find alternative protein sources for fish feeding, with special emphasis on terrestrial plants such as oilseeds and legumes (Glencross et al., 2007; Borquez et al., 2010). Many of these plants like soybean, peas and canola, played an important role as a good protein source for fish feed. Although algae are considered as a natural plant source for fish diets, soybean is still the most important plant source used in this field. Nowadays this plant has become one of the important biodiesel sources, which had resulted in raising its price. So numerous studies like (Ma et al., 2005, Valente et al., 2006, Soler-Vila et al., 2009, Abdel-Aziz and Ragab, 2017) have focused on using algae as ingredients in fish feed, determining the inclusion level of various algal species in aquafeeds and summarizing good results. Seasonal variations and knowledge about the effect of environmental factors on the biochemical composition of macroalgae are very important means for the evaluation of its nutritional values. In this context, some authors like Haroon et al., 1995, Haroon and Szaniawska, 1995, Haroon et al., 2000, Khairy and El-Shafay, 2013 had studied the seasonal variations in biochemical composition of some seaweeds.

Although, Qarun Lake is often inhibited by mixed stands of aquatic macroalgae, the biochemical composition of these macroalgae is still unknown. So the present study aimed to estimate the biochemical components of these macroalgae and determine the environmental factors which affect their structures. This was done as a way to evaluate its nutritional value as a natural source for fish feed.

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Materials and methods

Study area

Qarun Lake is a closed saline lake that lays in the northern part of El-Fayum Depression (Fig. 1) on 29° 30′ N, 30° 30 E, its maximal width is about 6.7 km and its length from east to west is about 40 km. The lake's surface area is about 243 km^2 and its maximum depth (~8.3 m) (El-Shabrawy and Dumont, 2009). It has no connection to the sea, and is directly sustained by the Nile River via Canal Bahr Yousef, which is the main source of water for the lake. Al-Batts and Al-Wady drains are the main sources of drainage water reaching the lake.

Samples collection

Due to the presence of macroalgae in high abundance during spring, both water and macroalgae samples were collected during spring 2017 from the shore's seven sites representing the main sectors (east, middle and west) of the lake. Where sites 1 (Senoris), 2 (Abu-Neema) and 3 (Shakshouk) represent the East, site 4 (Abu-Shanab) and 5 (El-Rawashdia) represent the middle and site 6 (Ayuob) and 7 (Qarun) represent the west of the lake (Fig. 1).

Physico-chemical parameters

At each sampling site the following environmental variables were measured. Water temperature (°C) and pH were measured in-situ using Hydrolab (Multi Set 430i WTW). Electrical conductivity was measured using a conductivity meter (S.C.T.33 YSI). Transparency was measured using a white/black Secchi disk (0.3 m in diameter). Water samples were kept in 2 L polyethylene bottles in an ice box and analysed in the laboratory. The methods of analyses were discussed in the APHA (2005). Salinity was determined by filtering a known volume of the sample by (GF/C) and evaporating it at 180 °C. Dissolved oxygen (DO) was measured using the modified Winkler method. Biochemical oxygen demand (BOD) was determined using the 5-day method. Chemical oxygen demand (COD) was carried out using the potassium permanganate method. Concentrations of NO_2^--N, NO_3^--N, NH_4^--N, PO_4^{-3}-P and SiO_4 were determined using colorimetric techniques with the formation of reddish purple azo-dye, Copper-Hydrazine sulfate reduction, phenate, ascorbic acid molybdate and molybdosilicate methods, respectively. Total phosphorus (TP) was measured as reactive phosphate after persulfate digestion and Total nitrogen (TN) was measured as nitrate after persulfate digestion then reduction by cadmium.

Fig. 1. Sampling sites for water and macroalgae collection in Lake Qarun during spring 2017.

Collection and drying of plant materials

The algal samples were hand-picked and kept in polyethylene bags with lake water to avoid cell lyses, a phenomenon that would lead to loss of organic matter. In the laboratory, they were separated into different taxa and were identified following the methods of Abbott and Hollenberg (1976) and Jha et al. (2009). The species names were identified according to Guiry and Guiry (2016). Algal samples were then cleaned and washed with water to remove the foreign particles; additional moisture was drained before being weighed and dried in shade. This was followed by another drying step in an oven at 60 °C to constant weight. The water contents (WC) were considered as the losses in weight from wet algal samples after drying at 60 °C to constant weight. The dry samples were then ground to fine powder and stored until analyses could be done.

Proximate analysis

Ash content was determined according to Pharmacopoeia, 1953. Lipid content was estimated following Bligh and Dyer (1959). The protein fraction was calculated using the nitrogen-protein conversion factor of 6.25 (Ölberg, 1956). Algal samples were digested to measure all their elements according to the method described by Peterburgski (1968). Total nitrogen (N) content was determined by Kejeldahl method (Black, 1965). Total phosphorus (P) measured colorimetry using the hydroquinone method (Snell and Snell, 1967). Sodium (Na) and potassium (K) were photometrically estimated as described by Brown and Lilland (1946) using Corning Clinical flame photometer 410C.

Calculated parameters

Digestible crude protein (DCP) was calculated following the equation of Demarquilly and Weiss (1970). The nitrogen free extracts (NFE) comprising of sugars, starches and a large part of the material classed as hemi-cellulose were calculated according to Pádua et al. (2004). Metabolized Energy (ME) was calculated according to Pantha (1982). The energy value (EV) was determined on the basis of the biochemical composition using the standard conversion factors (Brody, 1945).

Statistical analysis

Differences between macroalgae species and their components were determined by one-way analysis of variance (ANOVA) followed by Duncan's multiple range test at $p < 0.05$ using XL Stat version 2014. A multivariate technique, Canonical correspondence analysis (CCA), was used to summarize the changes of macroalgae components and their relation to environmental variables. CCA was performed using CANOCO V. 4.0 (Ter Braak, 1987).

Results and discussion

Physical and chemical variables

Temperature is one of the major factors affecting the aquatic (Abdo, 2003). It influences limnological phenomena such as stratification, gas solubility, pH, conductivity, degree of photosynthesis process by algae or larger aquatic plants and it affects the organisms (Nassif, 2012). However, in Lake Qarun, temperature appears to be in the ideal range for most of the aquatic organisms. The water temperature varied between a minimum of 22.6 °Cat site (2) and a maximum of 24.4 °C at site (7). During the present study, site 1 showed the lowest transparency values 35 Cm. However, the