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Full Length Article

Seasonal and spatial variation of aquatic macrophytes and phytoplankton community at El-Quanater El-Khayria River Nile, Egypt

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ABSTRACT

In this study, the phytoplankton biomass and species composition in El-Quanater El-Khayria (River Nile, Egypt) was analyzed at four sampling sites on a program of a seasonally sampling and supported by measurements of different water variables as well as biomass production of most common aquatic macrophytes. The major species of aquatic macrophytes were two submerged species (*Ceratophyllum demersum* and *Ceratophyllum submersum*), two emergent (*Polygonum tomentosum* and *spontaneum*), and one free floating aquatic macrophyte (*Eichhornia crassipes*). Considerable seasonal variations in water quality as well as macrophytes biomass were found in the studied areas, which result in a variation of phytoplankton flora. A total of 235 phytoplankton species belonging to 7 classes was recorded, with higher numbers in autumn and winter compared to spring and summer. The maximum number of phytoplankton ($7238 \times 10^4\,L^{-1}$ cells) was recorded in winter, however, the lowest one ($96 \times 10^4\,L^{-1}$ cells) recorded in spring. Chlorophyceae was the dominant group, forming 56.96% of the total phytoplankton biomass followed by Bacillariophyceae (34.82%), Cyanophyceae (7.99%), Cryptophyceae (0.10%), Dinophyceae (0.096%), Chrysophyceae (0.03%) and Euglenophyceae (0.02%). Chlorophyll *a* values ranged from $9.77\,\mu g\,L^{-1}$ to $69.81\,\mu g\,L^{-1}$, with a considerable seasonal and spatial variation. All phytoplankton classes as well as, chlorophyll *a* was negatively correlated with all aquatic macrophytes species except for *C. submersum* which correlated positively with chlorophyll *a* and Cyanophyceae. In addition, it was positively correlated with pH, conductivity and dissolved oxygen.

1. Introduction

The phenomenon of allelopathy refers to the mechanism, in which an organism releases specific chemical substances, which inhibit or stimulate the development and growth of neighboring organism (May and Ash, 1990). In addition, it may also play an eminent role in the occurrence or disappearance of specific species of organisms. In aquatic ecosystems, allelopathic interactions have been described for all groups of primary producing organisms, including macrophytes and phytoplankton (Ervin and Wetzel, 2003; Nan et al., 2008).

Phytoplankton taxa are the primary producers and represent the vital link in the aquatic food chain. Therefore, the whole pelagic ecosystem is regulated mainly by the phytoplankton (Jeffries and Mills, 1990). The variability of the phytoplankton in water bodies deepens on the physical and chemical characteristics of water (Nassar and Fahmy, 2016). These variations depend on the type and nature of the water area, as well as on the eutrophication process which refers as man-made activities and additions or runoff of minerals and chemicals from agriculture wastes (Viaroli et al., 2015).

In aquatic ecosystems, macrophytes contribute to sedimentation of particulate organic matter (Carpenter and Lodge, 1986). During growth and decay, macrophytes release dissolved organic matter, a by-product of photosynthesis (Perez and Sommaruga, 2006). These dissolved organic substances constitute a potential source of carbon for water column (Demarty and Prairie, 2009). An unknown fraction of plant-derived dissolved organic matter consists of biochemically active allelochemicals. These allelochemicals are chemically diverse secondary plant metabolites and exert multifunctional properties (Einhellig, 1995). When allelopathic substances are released into the water, they can inhibit the growth of epiphytes and phytoplankton and thereby provide a competitive advantage for the struggle of light, because they reduce the shading effect of phytoplankton up on the macrophytes. The allelochemical release has been confirmed for some common submerged macrophytes e.g. *Ceratophyllum demersum*, *Elodea* spp., *Myriophyllum* spp., *Najas marina* and *Stratiotes aloides* (Mulderij et al., 2005). However, nothing is known about the impact of emergent macrophytes on phytoplankton species. Thus, it is of interest to know the possible allelopathic effects of commonly distributed aquatic

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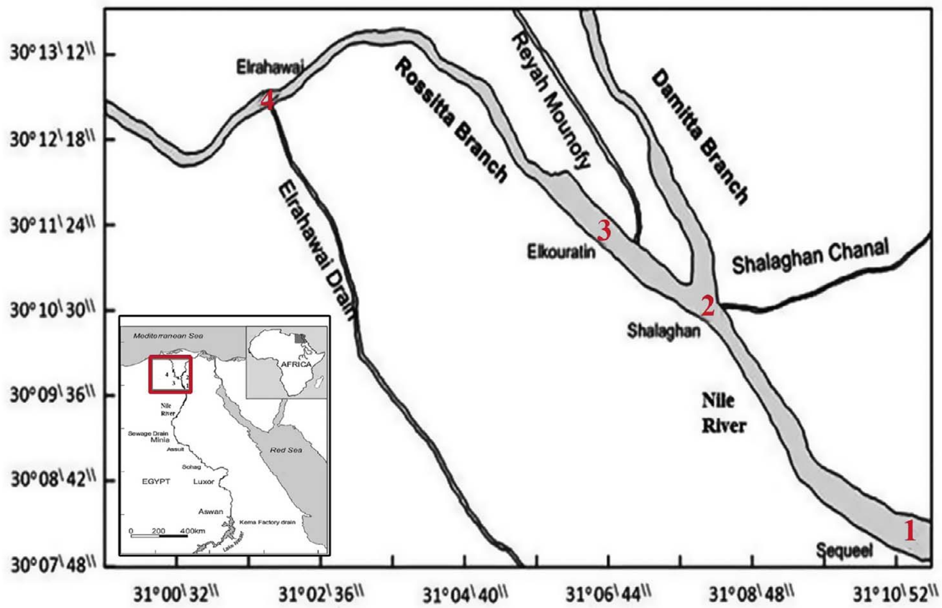

Fig. 1. Map shows the sampling sites.

macrophytes of the country, as well as the effect of water chemistry on the species composition of the phytoplankton flora at El-Quanater El-Khayria River Nile. Egypt.

2. Materials and methods

The samples of five macrophytic plants together with the corresponding water samples were collected seasonally months/season from four selected sites distributed along the River Nile (Fig. 1).

2.1. Physico-chemical characteristics

Seasonally water samples (four samples 1 L for chemical properties and determination of chlorophyll-*a*, and four 0.5 L samples for counting phytoplankton) were collected from the above-mentioned sites. Water pH and temperature were measured in the field using portable pH meter (Jenway 3250). Secchi disc of 25 cm diameter was used for measuring water transparency. Electrical Conductivity (EC) was measured in situ, using portable Hyrolab Analyzer model 340 i/set, Germany. Dissolved oxygen (DO) was estimated by the modified Winkler method (Thompson and Robinson, 1939).

Alkalinity was measured following APHA (1992), other physico-chemical parameters were measured colorimetrically (APHA, 1992, 1995) using spectrophotometer, model Kontron instrument NIKON 930 and were expressed as $\mu g\ L^{-1}$, except silicate salts, which expressed as $mg\ L^{-1}$.

2.2. Qualitative and quantitative and analysis of phytoplankton

For phytoplankton analysis 0.5 L water samples were fixed in the field with acid Lugol's Iodine solution (APHA, 1992). After sedimentation, algal species were identified and counted using a wild inverted microscope (Zeiss Axiovert 25C). Drop Method (APHA, 1992) was applied for both counting and identification of different algal species. Algal taxa were identified according to standard references, including Pascher (1976); Prescott (1978); Mizuno (1990); Popovsky and Pfiester (1990); Krammer and Lang Bertalot (1991). The results of calculation of phytoplankton were expressed as a number of cells L^{-1}, except for filamentous and colonial of blue-green algae which have been expressed as No. of units L^{-1}, where each unit equal to 100 μm length (in case of filamentous form) or diameter (in case of colonial forms).

2.3. Plant collection

The standing crop of the macrophytes was obtained following (Misra, 1968). The plant samples were collected seasonally using quadrates (50 × 50 cm). Plants of each quadrate were collected, weighted and the biomass of each plant species was measured separately and expressed as g wet weight m^{-2}.

2.4. Statistical analysis

Data are presented as mean ± SE and analyzed by one-way ANOVA to assess the significance using SAS program (1996).

3. Results and discussion

3.1. Physico-chemical characteristics

The chemical and physical characteristics of water are well known to control the life in aquatic habitats, lead to the appearance or disappearance of special types of biota (Fathi et al., 2001). The physical and chemical characteristics of the studied site's water were shown in Table 1. Temperature variations between the studied sites are presumably acceptable due to various reasons: depth of water, water quality, time of sampling, climatic conditions during the sampling period. In addition, the temperature was correlated negatively with conductivity, pH and dissolved oxygen and a positive with air temperature (Table 2). In agreement with the current results, Yoshida et al. (2016) attributed the fluctuations of temperature to the loss the oxygen content in the river water with harsh environmental consequences.

The annual mean values of pH at different sites were on the alkaline side (> 7). The relative increase in pH from 6.93 to 8.93 is mainly due to the increase in the photosynthetic activity (r = 0.442), which reduce the CO_2 amount in water. This is in agreement with Goldman (1972) who mentioned that the elevation of pH values always associated with the photosynthetic assimilation of dissolved inorganic carbon.

The obtained data showed that the lowest value of EC 123.50 ± 0.71 μmohs was recorded in spring at site 4, which may be attributed to the increase of water level. These results are in accordance with the results of Saad et al. (2011) which attributed this increase to flood period and the uptake of dissolved salts by phytoplankton. A highly significant positive correlations (r = 0.766, r = 0.602) were