ABUNDANCE AND BIOMASS OF FILAMENTOUS CYANOBACTERIAE IN A MEDITERRANEAN SALT MARSH

R. Rebai [1]*, N. Annabi Trabelsi [1], W. Guermazi [1], J. Elloumi [1], A. Bouain [1] and H. Ayadi [1]
[1] Université de Sfax, Faculté des Sciences de Sfax, Département des Sciences de la Vie. Unité de recherche UR/05ES05 Biodiversité et Ecosystème Aquatiques, Route soukra Km 3,5, B.P. 1171, CP 3000 Sfax, Tunisie - raydakobbi@yahoo.fr

Abstract
The aim of the present study is to understand the changes in the abundance and biomass of filamentous cyanobacteria with increase of salinity. Monthly samples over a period of one year (2007-2008) at three ponds (A1, A5 and C21) in the salt works of Sfax were collected and analyzed. Densities and biomasses of filamentous cyanobacteria decreased with the increase of salinity. This group uptake preferentially nitrites and ortophosphates at high salinities (> 62).
Keywords: Nutrients, Salinity, Cyanobacteria

Introduction
Phototrophic prokaryotes cyanobacteria are important primary producers especially in oligotrophic waters and the open ocean [1]. They have a higher nutrient affinity than eukaryotic algae, enabling them to grow under low nutrient concentrations [2]. They are thought to be favored by low (lower than 15) [3] N:P and Si:N ratios [4]. The objective of this study is to evaluate the influence of salinity increase on cyanobacteria abundance, biomass and nutrients uptake.

Materials and methods
Monthly samples were collected over a period of twelve months (September 2007 - August 2008) at three ponds (A1, A5 and C21) in the salt works of Sfax (central-eastern coast of Tunisia, about 34°, 390N and 10°, 420E). Salinity was estimated by the dry residue method, which consisted in evaporating a 50 ml sample (24 h, 120°C) in a previously sterilized crystallizing dish (by heating at 550°C for 1 h), and calculating the salt content from the difference in weight before and after evaporation. Samples for dissolved inorganic nitrogen (nitrite: NO_2^-, nitrate: NO_3^-, ammonium: NH_4^+), silicates $Si(OH)_4$ and orthophosphates (PO_4^{3-}) were stored at −20 °C before analysis with an automatic BRAN and LUE BBE-type 3 analyzer. Phytoplankton samples (200 ml) were fixed by Lugol-iodine solution (final concentration 1%, v/v) and counted under an inverted microscope (x 400) [5]. In this study, filamentous cyanobacteria were determined together with phytoplankton and not as single cells, e.g. *Synechococcus*, because we did not use epifluorescence. Biomass was calculated from mean biovolumes taking into consideration that 10^6 µm^3 = 1 µg (wet weight), assuming that organic cell carbon represented 12% of wet weight biomass. Pearson's correlation test was applied.

Results and discussion
The mean values found for all parameters during this study are summarized in Table 1.

Tab. 1. Average values of the biological, physical, and chemical parameters in three ponds (A1, A5 and C21) in Sfax salt works

Ponds	A1	A5	C21
filamentous cyanobacteriae density (ind.l^{-1})	1850	1025	400
filamentous cyanobacteriae biomass (µg.l^{-1})	667	309.8	150.9
Salinity	50.44 ± 7.12	62.79 ± 10.73	101.20 ± 12.58
NO_2^- (µmol. l^{-1})	0.25 ± 0.20	1.33 ± 2.24	0.54 ± 0.40
NO_3^-(µmol. l^{-1})	6.52 ± 3.73	2.4 ± 1.29	4.87 ± 2.59
NH_4^+(µmol. l^{-1})	5.21 ± 5.81	6.37 ± 5.73	3.82 ± 4.25
$Si(OH)_4$ (µmol. l^{-1})	12.65 ± 13.84	6.22 ± 6.66	7.41 ± 8.66
PO_4^{3-}(µmol. l^{-1})	19.19 ± 11.95	15.37 ± 5.06	13.86 ± 10.64

Microscopic counting of water samples showed that filamentous cyanobacteria constituted only a small proportion of the entire phytoplankton biomass ranging from 0.59% at C21 to1.91% at A. Although, Over the year, N:P and Si:N ratios were very low in the three ponds not exceeding 11.4 and 8.1 respectively. The phytoplankton biomass was dominated by small unicellular (protozoa) dinoflagellates and diatoms. The average abundance and biomass of filamentous cyanobacteria decreased with the increase of salinity. The highest mean was recorded at A1 and the lowest one was found at C21 (Table 1). The persistence of filamentous cyanobacteria in the extreme saline conditions exerted upon them some ecological challenges, e.g., the production of some extracellular enzymes [6]. Both filamentous cyanobacteria abundance and biomass showed highly significant positive correlations ($P<0.01$) with orthophosphates only at C21. They were able to accumulate phosphorus directly and they became enriched in phosphorus to a greater degree than other phytoplankton organisms [7]. Nitrites were preferentially and significantly used by filamentous cyanobacteria at A5 ($r= 0.996$; $P<0.01$) and C21 ($r= 0.845$; $P<0.01$).

References
1 - Glover, H.E., Campbell, L., Prezelin, B.B., 1986. Contribution of *Synechococcus* spp.to size-fractionated primary productivity in three water masses in the Northwest Atlantic. *Mar. Biol.* 91, 193-203
2 - Domingues R.B., A. Barbosa and H. Galvão., 2005. Nutrients, light and phytoplankton succession in a temperate estuary (the Guadiana, south-western Iberia), *Estuar. Coast. Shelf Sci***.** 64, 249–260.
3 - Sommer U., A., 1999. Comment on the proper use of nutrient ratios in microalgal ecology**,** *Arch. Hydrobiol. 146, 55–64.*
4 - Rocha C., H. Galvão and A. Barbosa., 2002. Role of transient silicon limitation in the development of cyanobacteria blooms in the Guadiana estuary, south-western Iberia, *Mar. Ecol. Prog. Ser.* 228, 35–45.
5 - Uthermöhl H., 1958. Zur vervollkommnung der quantative phytoplankton-methodik. Mitt. *Inst. Verh. Limn*. 9: 1-38.
6 - Zhang W., Y. Feng, 2008. Characterization of nitrogen-fixing moderate halophilic cyanobacteria isolated from saline soils of Songnen Plain in China. *Prog. Natural Sci*., 18: 769-773.
7 - Nausch M., G. Nausch, H. Ulrich Lass, V. Mohrholz, K. Nagel, H. Siegel, N. Wasmund., 2009. Phosphorus input by upwelling in the eastern Gotland Basin (Baltic Sea) in summer and its effects on filamentous cyanobacteria. *Estuar. Coast. Shelf Sci*.83: 434-442.