ELSEVIER

Ecological Indicators 7 (2007) 497–503

ECOLOGICAL INDICATORS

This article is also available online at:
www.elsevier.com/locate/ecolind

Short Communication

# On the relationship between ecology and phytoplankton composition in a karstic spring (Çepni, Bolu)

Abuzer Çelekli, Okan Külköylüoğlu *

*Department of Biology, Faculty of Arts and Science, Abant İzzet Baysal University, Gölköy, TR-14280 Bolu, Turkey*

Received 23 March 2005; received in revised form 10 February 2006; accepted 23 February 2006

**Abstract**

The phytoplankton assemblages and their relationship to physico-chemical environmental variables were studied in Akkaya spring, a limnocrene type of karstic spring pool, for 14 months from May 2003 to July 2004. A total of 63 taxa, belonging to *Bacillariophyta* (62%), *Chlorophyta* (29%), *Cyanophyta* (3%), *Pyrrophyta* (3%), *Euglenophyta* (2%), and *Chrysophyta* (2%), were found. According to CCA analysis, three environmental variables (conductivity, calcium, and sulphate) had the greatest influence on species composition. Based on their seasonal occurrence, most of the species found closer to the center of CCA diagram had cosmopolitan characteristics, while members of the genus *Spirogyra* were found together in the fall season. Similar seasonal patterns were also recorded in three other crustacean taxa including Cladocera (*Daphnia* sp.), Copepoda (*Cyclops* sp.), and Ostracoda (*Fabaeformiscandona fabaeformis*). Overall, the first two axes of CCA explained 97% of the relationship between species composition and environmental variables. This result was also supported by UPGMA analysis, where three main groups were clustered based on their binary data and ecological preferences. Although physico-chemical characteristics of the pool changed in the following months, after building of a concrete wall around the pool in October 2003, the long-term effect of such changes are not known at the moment.


*Keywords:* Phytoplankton; Ecological indicators; Karstic spring; CCA; Phenology; Bolu

## 1. Introduction

Phytoplankton compositions are affected by different environmental factors such as pH, light, and temperature (Buzzi, 2002). Besides their importance as the primary producers in food webs and ensuring ecological balance, species of phytoplankton can be useful indicators of water quality (Kitner and Poulickova, 2003; Rey et al., 2004). Although their capacity as indicator species is commonly recognized in the literature, there are few studies from Turkey. Limnological studies have gained momentum in Turkey in the last decades (e.g. Aykulu et al., 1983; Gönülol and Obalı, 1998; Aysel et al., 2002) but far from completion. Most of these studies are based on taxonomic levels above species, but few include

* Corresponding author. Tel.: +90 374 254 1226; fax: +90 374 253 4642.
*E-mail address:* kulkoyluoglu_o@ibu.edu.tr (O. Külköylüoğlu).

1470-160X/$ – see front matter © 2006 Published by Elsevier Ltd.
doi:10.1016/j.ecolind.2006.02.006

ecological data at the species level. Except some of the earlier studies on ostracods (Külköylüoğlu, 2004), there is no study focusing on phytoplankton assemblages in the karstic springs of Turkey. Akkaya spring is one of them, known for its special condition in which water quality and plankton composition seem to be affected by interactions of several chemical components. The purpose of this study was to investigate ecological determinants of phytoplankton composition and their seasonal occurrence in Akkaya spring.

## 2. Materials and methods

Akkaya (Çepni) spring (31°, 31′ E, 40°, 40′ N), 17 km southwest of the Bolu, Turkey is a karstic limnocrene spring located at about 1266 m above sea level (Fig. 1). Monthly samples of phytoplankton were obtained from May 2003 to July 2004 for about 14 months. Five environmental variables were measured in situ by using YSI-85 model oxygen-temperature meter, and pH and redox potential were determined using Hanna model HI-98150 pH/ORP meter. Atmospheric temperature and rainfall values were obtained from Bolu Meteorological Station. Chlorophyll-a concentrations were determined by spectrophotometry after extraction in 90% methanol (Youngman, 1978). Standard methods were used to determine chemical analysis.

The taxonomic keys of Krammer and Lange-Bertalot (1991a,b, 1999a,b) were used for diatom identification, while Prescott (1982), Huber-Pestalozzi (1983), Pfiester and Popovsky (1990), John et al. (2002), and Wehr and Sheath (2002) were followed for the identification of non-diatom phytoplankton species.

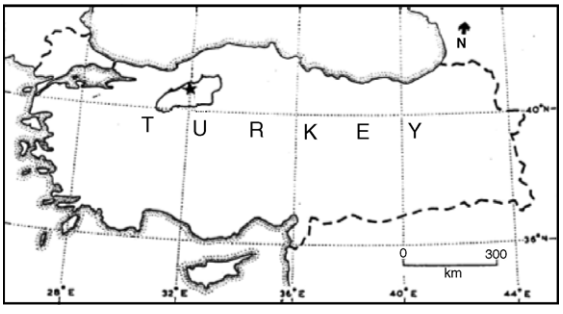


Fig. 1. Study site located in the city Bolu, Turkey.

We used canonical correspondence analysis (CCA) to determine the relationships between phytoplankton composition and physico-chemical environmental variables (ter Braak, 1995). A cluster analysis of unweighted pair group mean averages (UPGMA) was applied to discern different taxonomic assemblages among the species. All statistical analyses were conducted using the Multi-Variate Statistical Package (MVSP) program version 3.1 (Kovach, 1998).

## 3. Results

A total of 63 taxa (Table 1), belonging to six divisions *Bacillariophyta* (62%), *Chlorophyta* (29%), *Cyanophyta* (3%), *Pyrrophyta* (3%), *Euglenophyta* (2%), and *Chrysophyta* (2%) were found between May 2003 and July 2004. Among the taxa, *Asterionella formosa, Fragilaria capucina, Caloneis silicula*, and *Spirogyra longata* located close to the center of CCA diagram (Fig. 2) were found almost continuously during this study. Maximum numbers of species were identified in summer season, while minimum numbers were recorded in late autumn season. The first group of UPGMA dendogram (Fig. 3) includes seven taxa (*Spirogyra communis, S. dubia, S. majuscula, Spirogyra* spa., *Spirogyra* spx., *Cocconeis placentula* and *Peridinium willei*). The five species of *Spirogyra* were generally observed during late summer and fall months. The second group was composed of eight taxa, five of which (*Oscillatoria terebiformis, Trachelomonas* sp., *Ceratium hirundinella, Fragilaria dilata*, and *Navicula radiosa*) were found in moderately nutrient rich waters during the summer season. The third group includes the remaining 32 species, most of which have cosmopolitan characteristics known for their high levels of tolerance to changes in environmental variables.

Additionally, three accompanying zooplankton groups (Cladocera, Copepoda, and Ostracoda) were found from Akkaya spring during this study. A Holarctic ostracod species *Fabaeformiscandona fabaeformis* was found throughout the study, except in the onset of summer 2001, while the species of Cladocera (*Cyclops* sp.) and Copepoda were encoun-