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Flood pulse influence on phytoplankton community of the Aksu Stream, Giresun, Turkey

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Abstract

Flood pulse influence on phytoplankton communities of the Aksu Stream, Giresun, Turkey were studied between December 2008 and December 2009. The phytoplankton communities consisted of 54 species. The number of species and diversity of phytoplankton showed seasonal variation, being high in rainy season. As a consequence of the flood which occurred twice in July 2009, phytoplankton environment changed physically and chemically, which resulted in an alteration in the composition of phytoplankton community. The phytoplankton community that existed previous to the flood event, had been dominated by *Hantzschia amphioxys* but was replaced by *Nitzschia palea* and a teratological form of *Fragilaria* sp. Presence of teratological form of diatom in the stream indicated unfavourable conditions in this region.

Key words

Aksu Stream, Diversity, Flood pulse, Phytoplankton, Seasonal succession

Introduction

Flood pulse is known as the most important environmental factor in aquatic environment (Mihaljević *et al*., 2010). According to Junk *et al.* (1989), flood pulses are not considered a disturbance, though recent studies have proved that floods can be a disturbance factor for phytoplankton development (Paidere *et al*., 2007). Moreover, a dual impact on phytoplankton development in Danubian floodplain lake showed that early spring flooding had a stimulating effect, while flooding in late spring and in summer had a negative effect (Mihaljević *et al*., 2009).

Phytoplankton community structure in lakes is thought to be a well studied topic (Smith, 1990). Unfortunately, the picture of river phytoplankton is less clear. Most studies are only about species richness and many do not cover the entire seasonal variability and an ecological viewpoint (Rojo *et al*., 1994).

The distributions, abundance, species composition and diversity of phytoplankton are used to assess biological integrity of the aquatic environment (Townsend *et al*., 2000). Additionally, the knowledge of composition and diversity of phytoplankton constitutes an essential feature for the assessment of the trophic status in lakes and for the evaluation and utilization of different water resources. River floods have influences on ecological capacities of the river plankton. It is important to understand how a plankton community can be affected by floods, especially with regard to the problems of elevated concentrations and loads of organic matter (Pepelnik *et al*., 2005). The diatom cell can change in different ways and produce teratological forms due to exposure to different kinds of stress (Falasco *et al*., 2009). The aim of the study was to analyse flood pulse influence on phytoplankton communities of the Aksu Stream, Giresun, with respect to species richness, floristic composition, dominance and abundance of species. Rainfall, light and temperature are expected to be the major factors which influence phytoplankton succession and dominance.

Materials and Methods

The Aksu Stream (Giresun) is one of the main water streams of Giresun province located in the Eastern Black Sea Region of Turkey. Aksu Stream arises in the Karagöl Area (Giresun Mountains) is about 60 km long, 100 m wide at its mouth, and 3 m deep within the bar, which extends across the mouth, and shallow at places lying in its delta (Fig. 1). The area is characterized by the coastal Black Sea climate regime. The

Fig. 1 : Turkey and Aksu stream showing stations St.1, St.2, St.3 and St.4

weather is hot in summer, mild and rainy in winter. The amount of rainfall increases in July, August and December. The major floods occured twice in July 2009, at four stations. The data on temperature and rainfall, during the period, was taken from Meteorological Bulletin, Ankara, Turkey (Anonymous, 2009) and has been shown in Fig. 2.

Samples analysed in this work were collected monthly, in 2 l capacity Hydro-Bios water sampler to determine the diversity and abundance of algae during December 2008 and December 2009, from four stations and phytoplankton was estimated on subsamples preserved in acetic Lugol's solution. The valves of both normal and abnormal forms of *Fragilaria* sp. and other algae were counted on a Prior inverted microscope at 400 x magnification, following Lund *et al*. (1958). At least 200 individuals were counted. Bacillariophyta identified in permanent slides under oil immersion at 1000 x magnification (Round, 1953), were enumareted under Taxonomic identifications according to John *et al*. (2003); Krammer and Lange-Bertalot (1991a, b and 1999a, b). Changes in the phytoplankton community were examined with Cluster analysis using Bray-Curtis similarity matrices (Clarke, 1993). The software used was the program PRIMER version 5.0 from Plymouth Marine Laboratory for Cluster and Shannon-Wiener index (Shannon-Weaver, 1949).

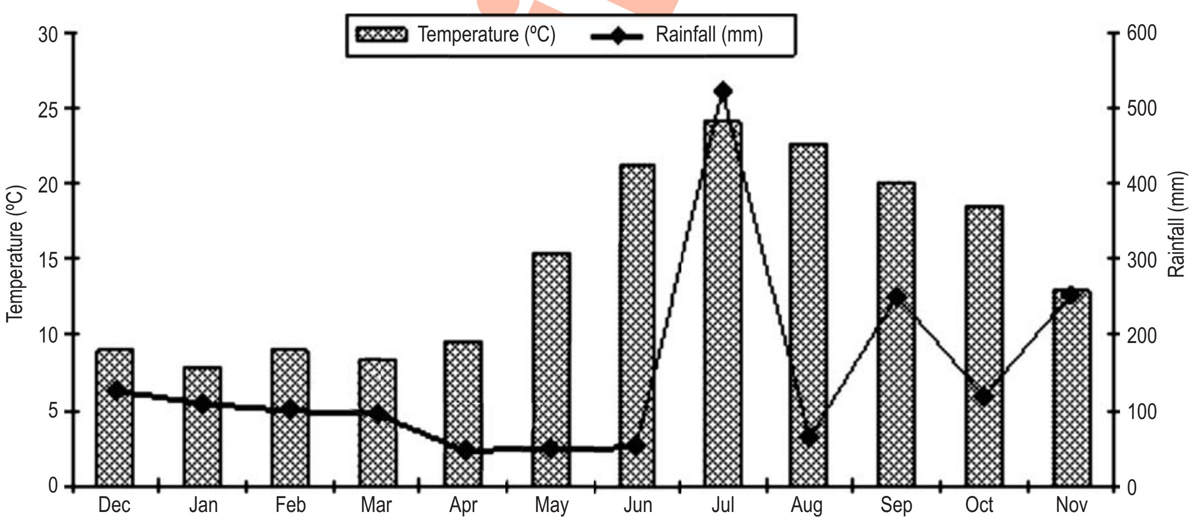

Fig. 2 : Mean air temperature (°C) and rainfall (mm) values for the region of Giresun from December 2008 to December 2009

Results and Discussion

A total of 54 planktonic algae were found: 38 Bacillariophyta, 7 Chlorophyta, 2 Euglenophyta, 6 Cyanophyta and 1 Cryptophyta (Table 1). Bacillariophyta were generally dominant among the planktonic algae in terms of the number of species. Chlorophyta were dominant in June at St. 3 and St. 4. During this month *Kirchneriella elongata* was dominant forming 57 % and 76 % of the total organism number. In the present study, in the former flood, abundance of Chlorophyceae was found, while in the latter, Bacillariophyta was found to be dominant (Train and Rodrigues, 1998) as in the studies of Fisher and Parshey (1979), Huszar (1994), Oliveira and Calheiros (2000). Cyanophyta increased their numbers during May at St. 3. and in March, May at St. 4. *Anabaena* sp and *Microcystis aeruginosa* were highly detected species with 1500 ind.ml^{-1} and 3000 ind.ml^{-1}, respectively (Fig. 3).

Seasonal variation of the total organism numbers was similar at all stations in the Aksu Stream. Peaks of phytoplankton were recorded in March, July and August due to high contribution of *Nitzschia palea*. In addition, *Kirchneriella elongata* provided an important contribution to the total organism numbers in June. Total organism numbers reached highest level with 580500 ind.ml^{-1}at St. 1 in July, after the flood event. *Nitzschia palea* were found to be dominant, and *Fragilaria ulna* were subdominant at all stations during this month.

After the floods, nutrient concentration increased due to washing out effect of the floodplain area. Which caused natural input and accumulation of organic matter from terrestrial vegetation (Mihaljević *et al.*, 2010). As expected, increase in phytoplankton abundance was seen due to higher nutrients than due to usual and mixed environment. Dominant phytoplankton species were diatoms during the study that was characteristic for

Table 1 : List of algae present in the phytoplankton in Aksu Stream

Taxons
Bacillariophyta
Centrales
Cyclotella ocellata Pantocsek
Melosira varians C. Agardh
Pennalas
Achnanthidium minutum Cleve
Cocconeis pediculus Ehr.
Cocconeis placentula Ehr.
Cymbella affinis Kütz.
Cymbella cistula (Ehr.) Kirchner
Cymbella caespitosa (Kütz.) Brun
Cymbella aspera var. aspera (Ehr.) H. Peragallo
Cymbella helvetica Kützing
Cymbella prostrata (Berkeley) Grun
Cymbella proxima R.M.Patrick
Cymbella tumidula var. lancettula Krammer
Cymbella ventricosa C. Agardh
Cymbella minuta var. minuta Hilse ex Rabenhorst
Encyonopsis microcephala (Grunow) Krammer
Diatoma vulgaris Bory
Fragilaria ulna (Nitz.) Lange Bertalot
Gomphonema olivaceum (Horn.) Breb
Gomphonema olivaceum var. olivaceoides (Hustedt) Lange-Bertalot
Gomphonema parvulum (Kütz) H.F. Van Heurck
Licmophora gracilis (Ehr.) Grun.
Hantzschia amphioxys (Ehr.) Grun.
Hantzschia sp.
Navicula cari Ehr.
Navicula cincta (Ehr.) Kirchner
Navicula cryptocephala Kütz
Navicula dicephala Ehr.
Navicula rhyncocephala Kütz.
Navicula tripunctata (O.F. Müler) Bory
Navicula veneta Kütz
Nitzschia acicularis (Kütz.) W. Smith
Nitzschia closterium (Ehr.) W. Smith
Nitzschia constricta (Kütz.) Ralfs
Nitzschia lanceolata W. Smith
Nitzschia palea (Kütz.) W. Smith
Meridion circulare (Greville) C. Agardh
Stauroneis anceps Ehr.
Chlorophyta
Chlorococcales
Ankistrodesmus falcatus (Corda) Ralfs
Ankistrodesmus spiralis (W.B.Turner) Lemmer.
Botryococcus braunii Kütz.
Kirchneriella elongata G. M. Smith
Kirchneriella lunaris var. contorta (Schmidle) Playfair
Kirchneriella lunaris var. obesa (G. S. West) Play
Desmidiales
Closterium sp.
Cyanophyta
Chroococcales
Chroococcus pallidus (Nägeli) Nägeli
Chroococcus turgidus (Kütz.) Nageli
Cylindrospermum stagnale (Kütz.) Born. & Flah
Hormogonales
Pseudanabaena limnetica (Lemmer.) Komarek
Phormidium limosum (Dilwyn) P.C. Silva
Nostocales
Anabaena sp.
Euglenophyta
Euglenales
Euglena sp.
Trachelomonas hispida (Perty) F. Stein

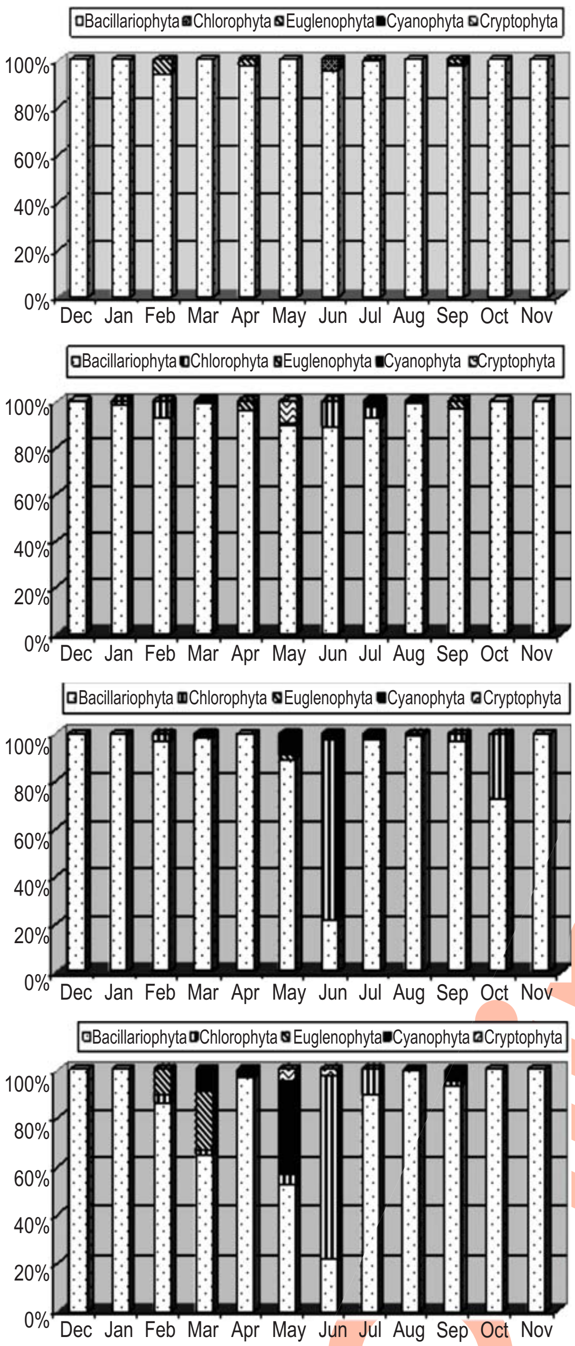

Fig. 3 : Density variation of total Bacillariophyta, Chlorophyta, Eulenophyta and Cyanophyta in Aksu Stream from December 2008 to December 2009 at sampling stations

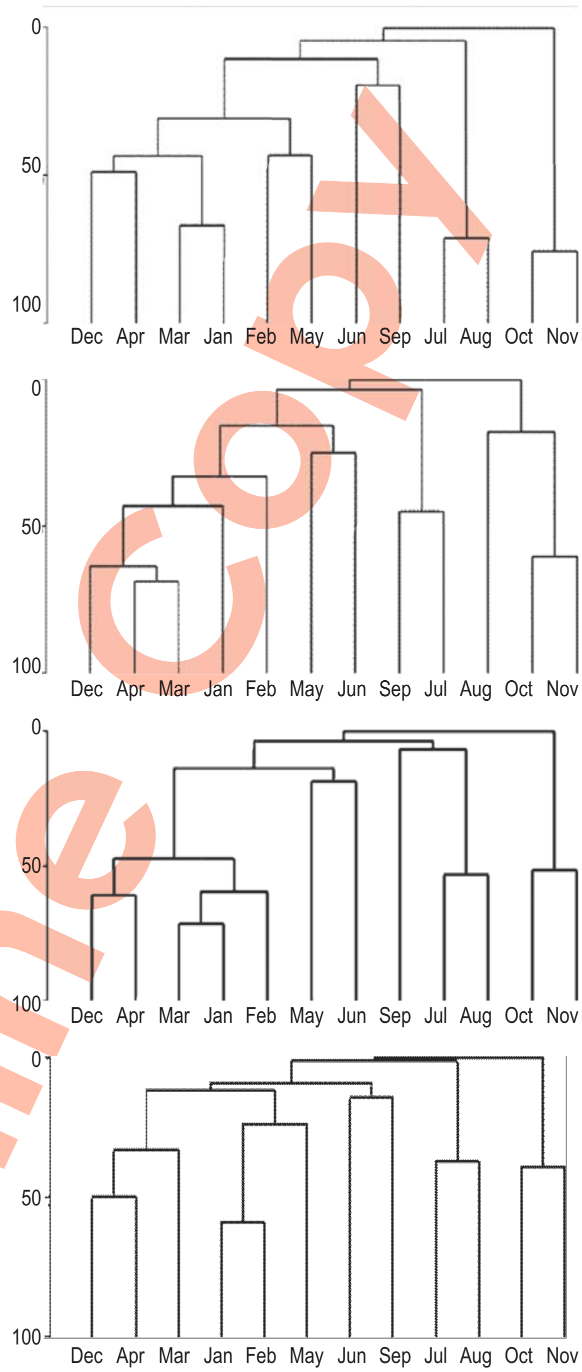

Fig. 4 : Dendrograms using complete linking of Bray-Curtis similarities at four sampling stations

a mixed, turbid environment. Mihaljević *et al.* (2009), Marshall (2009) and Rojo *et al.* (1994) also reached to a similar conclusion during their studies. Many diatoms, in the phytoplankton, resuspended from benthic origin with the help of flow that resulted from high rainfall and turbidity. Algal biomass is predicted to be reduced at high back-ground turbidity. Although *Cymbella, Nitzschia* and *Gomphonema* are generally benthic, many such species have been found in the phytoplankton of Aksu Stream.

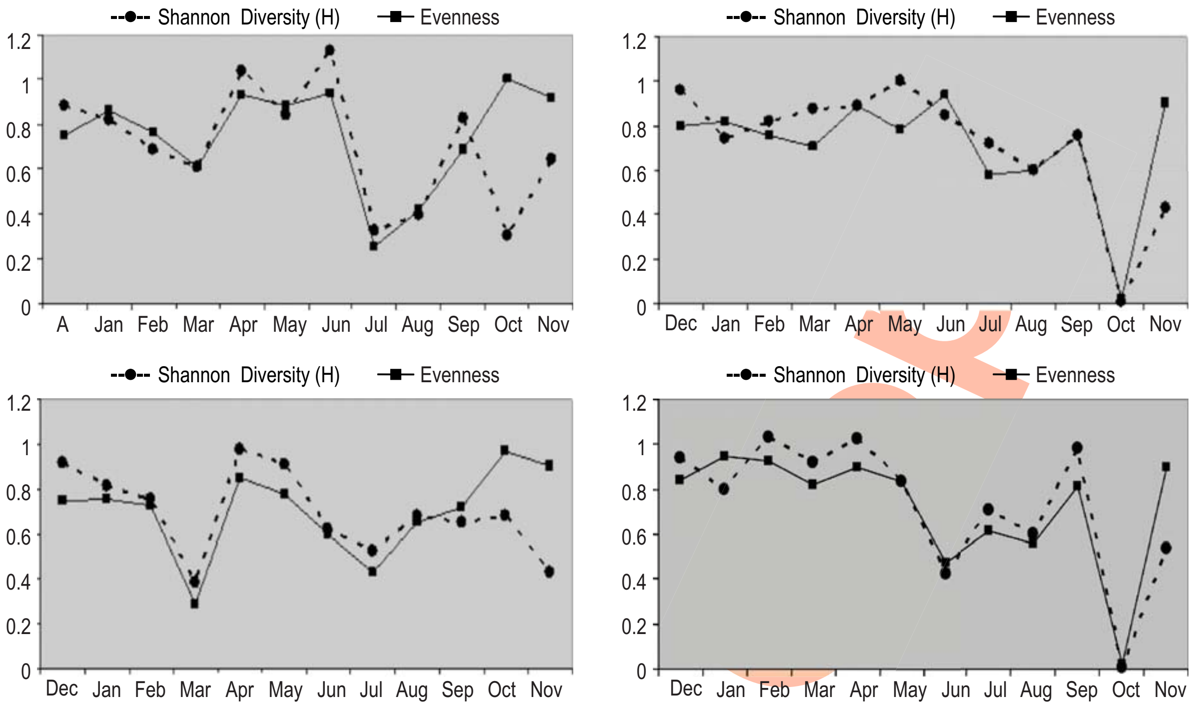

Fig. 5 : Shannon Diversity (H) and evenness variation in the phytoplankton community at four sampling stations in Aksu Stream

The results of this study showed that flood pulses can be a stimulating factor for phytoplankton development in the Aksu Stream. According to Mihaljević *et al.* (2009), lower phytoplankton biomass was established in summer due to dilution effect of flood pulses as a disturbance event. In another study on flood pulse in Pantanal Lake, Brazil, high phytoplankton biomass was found in the low water phase and peaks occurring in high waters (Loverde-Oliveira and Huszar, 2007).

In cluster graph the samples could be simply subdivided in two groups at the lowest hierarchical level at four stations. The first group was formed by October and November samples at all stations except St.1. The second group comprised all season samples. Association of January and February were most significant at St. 2, St. 3 and St. 4 . July and August comprised a group characterized by the dominance of teratological form of *Fragilaria sp* (Fig. 4).

The diversity index (*H)* ranged from 0.01 to 1.120 bits per mm^3. The lowest values for species diversity in the Aksu Stream occured during October at St. 2 and St. 4. (0.01 bits per mm^3) (Fig. 5). Relative species abundance (evenness) typically ranged from near 0, which indicated high-single species dominance (*Nitzschia palea*) at St. 2 and St. 4 during October. The bloom pattern of this species caused decrease of diversity, it also indicated low evenness. In October, evenness on a scale ranged from near to 1, which indicated maximum evenness at St.1. High species diversity values usually indicate diverse, well balanced communities, while low values indicate stress or impact. The potential for such low species diversity and biomass indicated substantial pollution (Bode *et al*., 2002). The most important stress on the Aksu Stream are flood pulses, organic enrichments, nutrients, pesticides and pollution loaded by canalisation (Anonymous, 2013) .

The number of species and density of phytoplankton showed marked seasonal variation, being high in rainy season. Total organism numbers reached highest level in July which corresponds to highest rainfall (521 mm) during same month. In contrast to Piirsoo *et al.* (2008), higher phytoplankton biomass coincides with high water level in the stream. As a consequence of flood, the phytoplankton environment was changed physically and under went a change resulting in alteration in the composition of the phytoplankton community. The phytoplankton community which existed previous to the flood event, was dominated by *Hantzschia amphioxys* but was replaced by *Nitzschia palea* and a teratological form of *Fragilaria sp.* The presence of the teratological form of diatom in river may indicate unfavourable conditions in this region. Unfavourable environmental conditions impact not only the life cycle of diatoms but also valve morphologies. As expected, valve morphologies of unfavourable environmental conditions are different from those of undisturbed environments (Dzieng-Czaja *et al.,* 2008).

In the Aksu Stream, seasonal variation of phytoplankton species was strongly influenced by meteorological and hydrological events. Meteorological events like heavy rainfall leading to a flood, hot weather periods and stormy days can have a pronounced impact on hydrodynamics, water temperature and nutrient supply. High contribution of diatoms was the most characteristic feature concerning the quantitative composition of phytoplankton. Although diatoms are known to be morphologically and physiologically adapted to grow in mixed and turbid environments, teratological forms of *Fragilaria* sp. was determined in the study area after the great flood event occured in July, in the Aksu Stream. Teratological forms appear as an accidental effect of environmental stresses, which can be both physical and chemical (Falasco *et al.,* 2009). The results of this study showed that flood pulses can be a stimulating factor for phytoplankton development in the Aksu Stream.

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