OPEN ACCESS
International Journal of Aquatic Science
ISSN: 2008-8019
Vol. 8, No. 1, 3-8, 2017

IJAS

Determination of environmental factors and littoral phytoplankton in Izmit Bay

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Received: November-10-2016 **Accepted:** December-30-2016 **Published:** January-01-2017

Abstract: In this study it is aimed to determine the relationship between environmental parameters and phytoplanktonic communities from six selected sampling sites in the littoral region of Izmit Bay. The samples were taken monthly from January 2011 to December 2011. Twenty taxa were identified in the phytoplankton. Although the distribution of species varied from station to station, *Cocconeis scutellum* Ehrenberg and *Oscillatoria* sp. were identified as the most abundant in the phytoplankton. Water temperature, pH and conductivity varied from 9.2 - 25 °C , 6.9-8.3, 30.5-45.1 µS/cm, dissolved oxygen values as minimum and maximum 4.6–12.7 mg l^{-1} were determined respectively. The water quality parameters were analyzed one-way ANOVA and differences were evaluated with Duncan's test. In the study was done the canonical correspondence analysis (CCA).

Keywords: Phytoplankton, Water quality parameters, Sea, Statistic

Introduction

Izmit Bay is one of the most important for sea transportation and industry in Turkey. The bay is subjected to over-population and there are many industrial activities, chemical and domestic wastes and biological pollution. There are several studies related to the water quality and the sources of pollution of the Izmit Bay (Morkoç *et al*.,1994; Legoviç *et al.,*1994; Morkoç *et al*.,1995; Morkoç *et al.*1997; Aktan *et al.*2005; Algan *et al.,* 1999; Tarkan *et al*.,2000; Morkoç *et al*.,2001; Morkoç *et al*.,2007; Morkoç *et al*.,2008; Küçük and Ergül, 2011). Among the variety of living things algae are important because they are the first part of the food chain. They ensure ecological balance and contain the species which are important indicator taxa in the determination of water pollution (Ertan and Morkoyunlu, 1998). In this study aimed to determine the relationship between environmental parameters and phytoplanctonic communities.

Materials and Method

Study Area

Izmit Bay is an approximately 50 km long, narrow marine space located at the eastern end of the Marmara Sea. The bay is located between the coordinates of 29°37.16' and 29°56.70' E and 40°39.73' and 40°49.46' N. Izmit Bay has a surface area of 261 km^2 and 1.8-9 km. wide. (Morkoç *et al*., 1994).

Monthly samples of phytoplankton were taken from six stations in Izmit Bay from January 2011 to December 2011 (Fig.1). Water temperature, pH, conductivity, (with CTD probe, YSI Incorporated) and dissolved oxygen were measured at each surface. During the study, the samples were collected monthly from each sampling station using plankton net. Permanent slides were prepared after boiling the diatom samples with acidic solution and than the diatom samples were fixed in Entellan medium. Taxonomic identifications were made according to literature (Cupp,1943; Kramer and Lange-Bertalot,1986; Tomas,1995; Anonymous, 2015) . The water quality parameters were evaluated with Duncan's Post Hoc Tests within the analysis of variance (ANOVA) design of SPSS 9.0® for Windows (Anonymous, 2004). The relationships between the species and the environmental variables were determined using multivariate analyses. In the analysis, an unconstrained ordination was calculated to select a linear or unimodal method: detrended correspondence analysis (DCA). The data were transformed logarithmically [log (a × y + b)]. Through detrending by segments in DCA and Hill's scaling, the length of the longest axis provided an estimate of the beta diversity in the data set. Since DCA showed short gradient lengths (<1.2 SD), a linear model was

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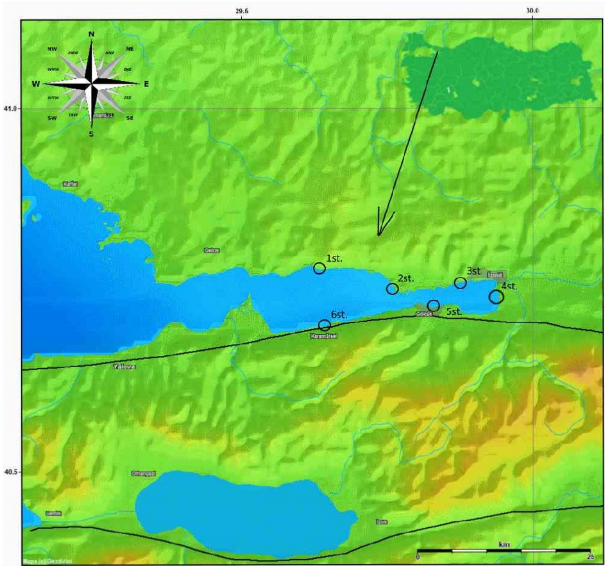

Fig. 1: Map of the study area.
(http://www.koeri.boun.edu.tr.sismo.map)

appropriate for our data (Lepš and Šmilauer, 2003). Canonical correspondence analysis (CCA), scaling on interspecies correlations and dividing species scores by the standard deviation, was then used. Logarithmically transformed data were centered (Ter Braak, 1986; Ter Braak and Verdonschot, 1995; Lepš and Šmilauer, 2003).The generalized linear model (GLM) is an advantageous univariate analysis method because it allows for nonlinear and nonnormal responses. It was performed to simulate the response of species abundance to predictor variables that prefer logarithmic link functions and Poisson distributions (Lepš and Šmilauer, 2003). Multivariate analyses and the GLM were performed using CANOCO ®version 5.0.

Results

A total of 20 taxa belonging to Cyanobacteria (2), Miozoa (2), Bacillariophyta (14), Euglenozoa (1), Chlorophyta (1) were identified in Izmit Bay. A list of the species was given in Table 1.

The abundance rates of the total phytoplankton species varied according to the stations and research period. The annual variations of the phytoplankton divisions and physico-chemical parameters and Correlations between water quality parameters and phytoplankton according to canonical correspondence analysis (CCA) were given in Figures 2-7 and Table 2.

Discussion

In the study, Bacillariophyta taxa were determined to be higher than the other groups. This is due to their high ecological tolerance of diatom species. Species diversity was found high in the spring time. The qualitative and quantitative differences between the identified microalgae are related to the wave movement in the stations, the condition of being used for domestic or industrial purposes and the dissolved substance contents in the water. However, at Station 3, it was determined that the distribution of the species indicating pollution is more dominant than that of other species. *Cocconeis scutellum* Ehrenberg, *Navicula lanceolata* Ehr., *Oscillatoria* sp. are the species that were identified the most in this station. *Cocconeis scutellum* is cosmopolitan, epiphytic and bentic occuring in marine and brackish water both polluted and healthy environments (Anonymous, 2015). *Navicula lanceolate* was determined in freshwater and slightly brackish water environment. This type of widely available in the 3rd station, located in this area is thought to be have been caused by dirty stream flow. Determined *Navicula lanceolata* and types of pollution tolerance is high, especially *Oscillatoria* sp. It is defined as the pollution indicator (Veziroglu, 1984). The dominance of the species that indicate pollution in the 3rd station is due to the fact that the area is used as a fishing port and it is highly prone to allochthonous factors. In terms of species distribution is determined that a structure similar to the other station.

Tab. 1: The List of Phytoplankton in Izmit Bay.

Bacillariophyta
Achnanthes brevipes C. Agardh
Amphora ovalis (Kütz.) Kützing
Cocconeis scutellum Ehrenberg
Coscinodiscus concinnus W. Smith
Gomphonema geminatum (Lyngbye) C. Agardh
Cymbella subturgidula Krammer
Fragilaria crotonensis Kitton
Licmophora gracilis (Ehrenberg) Grunow
Navicula lanceolata (C. Agardh) Kützing
Navicula pennata A. Schmidt
Nitzschia sigma (Kützing) W.Smith
Pseudo-nitzschia delicatissima (Cleve) Heiden in Heiden & Kolbe
Surirella gemma (Ehrenberg) Kützing
Synedra ulna (Nitzsch) Ehrenberg
Chlorophyta
Tetraselmis sp.
Cyanobacteria
Synechococcus sp.
Oscillatoria sp.
Euglenozoa
Euglena viridis (O.F.Müller) Ehrenberg
Miozoa
Tripos furca (Ehrenberg) F.Gómez
Ceratium fusus (Ehrenberg) Dujardin

The monthly average water temperature varied from 9.2^{o}C to 25^{o}C. The highest and lowest temperatures were in July and February, respectively. The pH values fluctuated between 6.9 and 8.3. The dissolved oxygen concentration was between 4.6 and 12.7 mg l^{-1}. The electric conductivity values were between 30.5 and 45.1 µS/cm. The maximum value of water temperature (25^{o}C) was obtained at Station 3 (May and July 2011), while the minimum value (9.2^{o}C) was measured at Station 1 (February 2011). The difference between the temperature averages by months for the stations was determined to be insignificant (ANOVA) P>0.05) (Fig. 2). The dissolved oxygen in the surface water was generally oversaturated, due to the exchanges with the atmosphere and algal productivity. The maximum value (12.7 mg l^{-1}) was obtained at Station1 (May 2011), while the minimum value (4.6 mg l^{-1}) was measured at Station 3 (July2011). While the difference between the monthly dissolved oxygen mean values of Station 2 and 5 and those of Station 1, 4 and 6 was found to be insignificant (P>0.05), the difference between Station 3 and the other stations was found significant (P<0.05) (Fig. 3). The maximum pH value (8.3) was obtained at Station 6 (December 2011), while the minimum value (6.9) was measured at Station 1 (March 2011). The difference between the pH values of Station 1 and those of Station 5 and 6 was found significant (P<0.05), whereas the differences between the others were determined to be insignificant (Fig. 4). The maximum conductivity value (45.1) was obtained at Station 3 (April 2011), while the minimum value (30.2) was measured at Station 6 (March 2011). The difference between the monthly average conductivity of Station 2 and those of Station 1, 3 and 5 was insignificant, whereas the difference between the average conductivity of Station 4 and 6 and those of the other stations was significant (P<0.05), (Fig. 5).

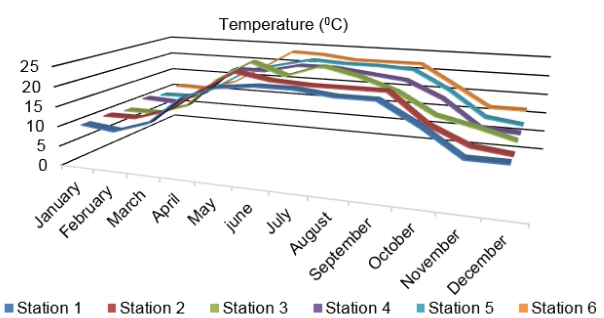

Fig. 2: The temperature values in the stations.

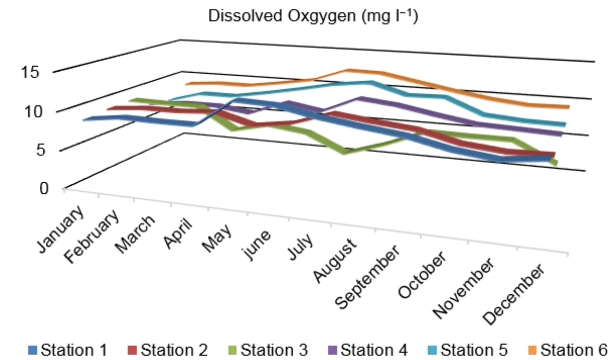

Fig. 3: The dissolved oxygen values in the stations.

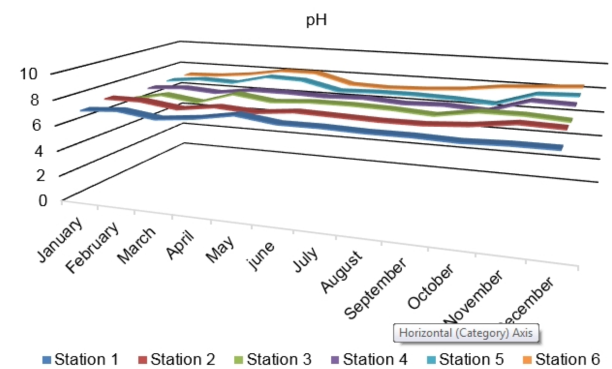

Fig. 4: The pH values in the stations.

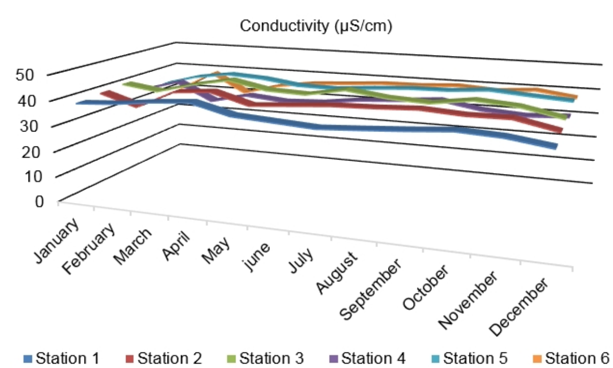

Fig. 5: The conductivity values according to the stations.

It was determined that the water temperatures measured were seasonally parallel to each other, and that the reason for the measurement of the highest temperature in the 3rd station was the fact that the water movement in the area of the 3rd station was quite stable. Throughout the research period, the lowest dissolved oxygen value was recorded to be 4.6 mg/L in July 2011 in the 3rd station, while the highest value of 12.7 mg/L was measured in May 2011 in the station 1. The measured dissolved oxygen levels showed that they increase in winter months in line with the decreasing temperature, and that they decrease significantly in the summer period with the increase in the temperatures. Thus, it was also determined in this study that there is a negative correlation between the temperature and the dissolved oxygen concentration. The fact that the lowest value of oxygen was measured in the 3rd station is considered to be due to the highly polluted condition of the area and due to the dissolution of the organic wastes in the water. While the lowest pH value in Izmit Bay was measured to be 6.9 in the 1st station in March, the highest pH value of 8.3 was recorded in the measurement carried out in December 2011 in the 6th station. Examining the stations in terms of pH values showed that the sea water exhibit slightly alkaline characteristics. The measured pH values varied between the values of 6.9 and 8.3 throughout the year. It is considered that Station 3 is of a different structure than the other stations, it is polluted by industrial and domestic wastes, due to the low water depth in the area the water is mostly stable, which increases pollution load, and these values were found out to be high due to the lack of circulation in the area.

Species and environmental parameters were evaluated according to canonical correspondence analysis. CCA revealed that the first two axes explained 72.2% of the variation in species–environment relationships. The first axis explained 49.8% and the second axis explained 22.4% of the total variation. The first factor explained 4.8% of the species variation and 50% of the total variation. The second factor explained 22% of the total variation (Tab. 2). Temperature, pH and DO have higher correlation ordination axis. Temperature is the most important variable for species abundance and distribution (Fig. 6).

Tab. 2: Total variance explained with CCA.

Axes	1	2	3	4	Total inertia
Eigenvalues	0.243	0.109	0.076	0.059	5.038
Species-environment correlations	0.724	0.585	0.527	0.455	
Cumulative percentage variance of species data	4.8	7.0	8.5	9.7	
of species-environment relation	49.8	72.2	87.8	100.0	

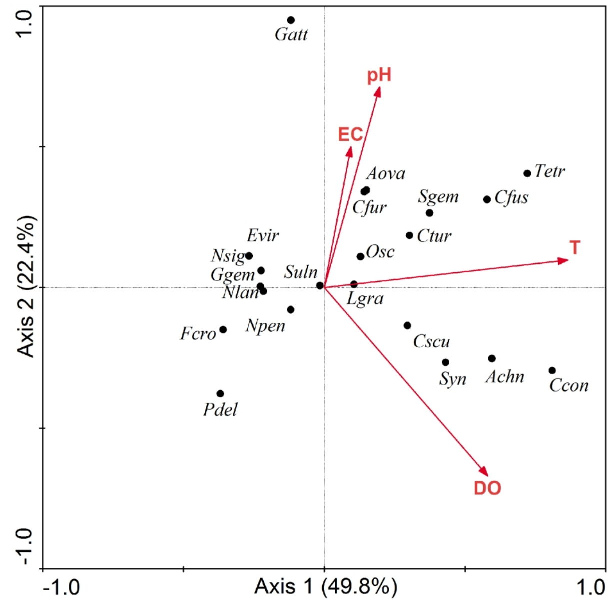

Fig. 6: Correlations between water quality parameters and phytoplankton according to canonical correspondence analysis (CCA).

The GLM simulated the monthly succession based on the abundance response of the taxa to temperature changes in the water column of Izmit Bay (Fig. 7) Algal abundance was defined by high numbers around 15 °C, which was near the annual mean temperature in the water column. The GLM roughly classified *Fragilaria crotonensis* Kitton as dominant below 10°C, while *Oscilatoria* sp. *Cocconeis scutellum* Ehrenberg, and *Achnanthes brevipes* C.Agard were dominant around 15°C and above 15°C, respectively. *Synedra ulna* (Nitzsch) Ehrenberg showed a positive linear relation with temperature. The model explained the maximum growth under the higher temperature conditions in summer for species such as *Oscilatoria* sp., *Cocconeis scutellum* Ehr. and *Achnanthes brevipes* C.Agard.

GLM (General Linear Model) procedure was used in order to see the effect of temperature on the species in more detail. According to this analysis, although *Fragilaria crotonensis* Kitton was abundant below 10°C, it has a negative correlation with temperature. This species preferred low water temperature. Other species of *Oscilatoria* sp., *Cocconeis scutellum* Ehrenberg, and *Achnanthes brevipes* C.Agard. preferred temperatures of 15°C and above and their concentration showed an increase in temperatures above 15°C. Another species of *Synedra ulna* (Nitzsch) Ehrenberg was observed to have a positive linear relationship with temperature. The model explains the increase in the concentration of the species such as *Oscilatoria* sp. *Cocconeis* *scutellum* Ehrenberg, and *Achnanthes brevipes* C.Agard. In summer months when water temperature is high.

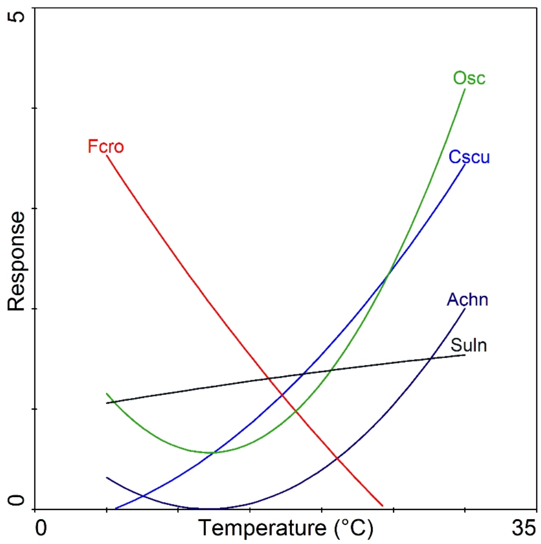

Fig. 7: Correlations between temperature and phytoplankton (Achn: *Achnanthes brevipes,* Cscu: *Cocconeis scutellum,* Fcro: *Fragilaria crotonensis,* Osc: *Oscilatoria* sp., Suln: *Synedra ulna*).

As a result, in this study determined that temperature was playing important roles as limited factors to phytoplankton. Seasons are important in the development of some species. It was determined that the physical and chemical parameters of the sea water in Izmit Bay comply with previous studies carried out in this region. When the species identified in the study were evaluated with the previous studies for the region, qualitative and quantitative differences were identified. This difference is thought to be due to the years of the researches, selected stations and changing eco-biological parameters (Morkoç *et al.*,1994; Legoviç *et al.*,1994; Morkoç *et al.,*1995; Morkoç *et al*.,1997; Aktan *et al*.,2005; Algan *et al.*, 1999; Tarkan *et al*.,2000; Morkoç *et al*.,2001; Morkoç *et al.,*2007). In the study, it is concluded that wave motions in aquatic environments and water quality parameters are primarily effective in the distribution of phytoplankton taxa.

Acknowledgements

I would like to thank Dr. Tekin Yeken from University of Kocaeli, and Dr. Yıldız Bolat from University of Süleyman Demirel and, Dr. Vedat Yegen from Republic of Turkey Ministry of Food, Agriculture and Livestock, Aqua. Res. Stat.,they provided full support.

References

- ✓ Aktan Y., Tufekçi V., Tufekçi H. and Aykulu G. (2005) Distribution patterns, biomass estimates and diversity of phytoplankton in Izmit Bay (Turkey). Estuarine, Coastal and Shelf Science, 64: 372-384.
- ✓ Algan O., Altıok H. and Yüce H. (1999) Seasonal variation of suspended particulate matter in two-layered İzmit Bay, Turkey, Estuarine, Coastal and Shelf Science, 49: 235-250.
- ✓ Anonymous (2004) SPSS INC, SPSS Proffessional Statistics 13.0 SPSSINC, Chicago.
- ✓ Anonymous (2015) http://www.algaebase.org. (date of access 15.04.2015)
- ✓ Cupp E.E. (1943) Marine Plankton Diatoms of the West Coast of North America, Univ. of California Press (Reprint 1977 by Otto Koeltz Science Publishers) 237 p.
- ✓ Ertan O. and Morkoyunlu A. (1998) The Algae Flora of Aksu Stream (Isparta -Turkey), Turkish Journal of Botany, 22: 239-255.
- ✓ Kücük A. and Ergül H.A. (2011) Seasonal variations of microplankton composition in İzmit Bay (Sea of Marmara), J. Black Sea/Mediterranean Environment, 17: 216-222 .
- ✓ Kramer K. and Lange-Bertalot H. (1986) Süsswasserflora Von Mitteleuropa, Bacillariophyceae, Band 2/3. 3. Teil, Gustav Fisher Verlag, 576 p.
- ✓ Lepš J. and Šmilauer P. (2003) Multivariate Analysis of Ecological Data Using CANOCO. 1st ed. Cambridge, UK: Cambridge University Press, 283 p.
- ✓ Legovic T., Morkoç E., Okay O.S., Egesel L., Tufekçi V. and Tufekçi H. (1994) Mass balance of total phosphorus in the Izmit Bay. International Specialized Conference on Marine Disposal Systems. Nov: 345-350.
- ✓ Morkoç E., Tugrul S., Okay O.S. and Legovic T. (1994) Eutrophication, limiting nutrient and hydrochemical characteristics of the polluted Bay of Izmit, result of four-years data. International Specialized Conference on Marine Disposal Systems., Nov.:335-344.
- ✓ Morkoç E. and Tugrul S. (1995) Effect of wastewater pollution on the physical and biochemical properties of the Bay of Izmit. Journal of Nature - Tr. Engineering and Environmental Sciences, 19: 87-96.
- ✓ Morkoc E., Tugrul S., Okay O. and Legovic T. (1997) Eutrophication of the Izmit Bay, Marmara Sea., Croatica Chemica Acta, 70: 347-359.
- ✓ Morkoç E., Okay O.S., Tolun L., Tufekçi V., Tufekçi H. and Legovic T. (2001) Towards a Clean Izmit Bay. Environment International, 26: 157–161.
- ✓ Morkoç E., Legoviç T., Okay O., Tufekçi H., Tufekçi V., Tolun L. and Karakoç F. (2007) Changes of oceanographic characteristics and the state of pollution in the İzmit Bay following the earthquake of 1999. Environmental Geology, 53: 103-112.
- ✓ Morkoç E., Okay O.S. and Edinçliler A. (2008) Land-based sources of pollutants along the Izmit Bay and their effect on the coastal waters. Environmental Geology, 56: 131-138.
- ✓ Tarkan A.N., Morkoç E., Sever T.M. (2000) Dominant

zooplankton species in the Bay of İzmit. Marmara Sea 2000 Symposium Book of Declarations, TUDAV, 468-474.

- ✓ Ter Braak C.J.F. and Barendregt L.G. (1986) Weighted averaging of species indicator values: its efficiency in environmental calibration. Mathematical Biosciences, 78: 57-72.
- ✓ Ter Braak C.J.F. and Verdonschot P.F.M. (1995) Canonical correspondence analysis and related multivariate methods in aquatic ecology. Aquatic Sciences, 57: 255-264.
- ✓ Tomas C. (1995) Identifying Marine Diatoms and Dinoflagellates, Academic Press, Inc. 598.
- ✓ Veziroglu T.N. (1984) The Biosphere Problems and Solutions, Elsevier Science Publishers. 437-460.