

Assessment of Surface Water Quality in Biga Stream (Canakkale/Turkey)

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Abstract
Assessment of water quality is a major objective in the management of water organizations, since the water quality may pose a health risk for animals and humans. The study herein focuses on quality of Biga stream, for 12 months and also the variation in culturable heterotrophic bacteria abundance between stations is examined. Based on results of comparison data with Turkish legislation, it is seen that waters of Biga stream belonged to Class 1 for parameter temperature, dissolved oxygen; belonged to Class 2 for biochemical oxygen demand, pH and total coliform; belonged to Class 3 for electrical conductivity and belonged to Class 4 for faecal coliform. MANOVA were used to compare spatial-temporal variations on physicochemical and microbiological parameters. While there was a statistically significant difference ($p < 0.05$) in terms of Temperature, Dissolved Oxygen and pH between seasons, there was no significant difference between the stations. And there was a statistically significant difference ($p < 0.05$) between stations and seasons in terms of Total coliform, Faecal coliform and Faecal streptococci; Heterotrophic plate count (+ 35ºC) and Faecal streptococci, respectively. It is therefore strongly necessary to monitor water quality and control the release of untreated wastes into the stream.

Keywords: Biga Stream monitoring, Water quality, Culturable heterotrophic bacteria, Abiotic factors

1. Introduction
Stream water quality is of great environmental concern since it is one of the major available fresh water resources for human consumption. Anthropogenic activities such as urban, industrial, and agricultural as well as natural processes, such as precipitation inputs, erosion, and weathering of crustal materials affect stream water quality and determine its use for various purposes (Bhat et al., 2014). Quality evaluation of

the fresh water quality can be complex process involving numerous parameters which contribute with different pressures on water quality (Radu et al., 2014). These parameters are microbial and physicochemical parameters which could be affected by external and internal factors. There is also an intricate relationship between the external and internal factors in aquatic environments. Meteorological events and pollution are a few of the external factors which affect physicochemical parameters such as temperature, pH and dissolved oxygen of the water. These parameters have major influences on biochemical reactions that occur within the water. Sudden changes of these parameters may be indicative of changing conditions in the water. Internal factors, on the other hand, include events, which occur between and within bacterial and plankton populations in the water body (Bezuidenhout et al., 2002).
Considering spatial and temporal variations in hydrochemistry of streams, regular monitoring programs are required for reliable estimates of water quality. This result in enormous and complex data matrix comprised of a large number of physical, chemical and microbiological parameters, which are often difficult to interpret rendering meaningful conclusions (Gonzalez et al., 2011). In the world there are a great deal investigations about fresh water quality (Gasim et al., 2007; O'Neal and Hollrah, 2007; Yilia et al., 2007). But there is not sufficient study about Biga Stream in Canakkale except three investigations (Yayintas et al., 2007a,b; Hacioglu and Dulger, 2009).
The study herein focuses on stream water quality of Biga stream, for 12 months in the October 2013 - September 2014 period, using some statistical methods. Also the variation in culturable heterotrophic bacteria abundance between stations is examined.

2. Material and Methods

2.1. Study area

The Biga stream is located in the southwest region of Marmara, latitude 40º 15' to 40º 27' N and longitude 27º 13' to 27º 28' E, in Canakkale, Turkey (Figure 1). The study area is the most important lowland in the Marmara region. Its mean depth is 50 cm and flow speed is between 5 and 15 m3 s−1. This water resource is used for agriculture as on irrigation water and drinking water for animals (such as cows, sheep and birds) (Hacioglu and Dulger, 2009). Description of sampling sites is written below (Figure 1).

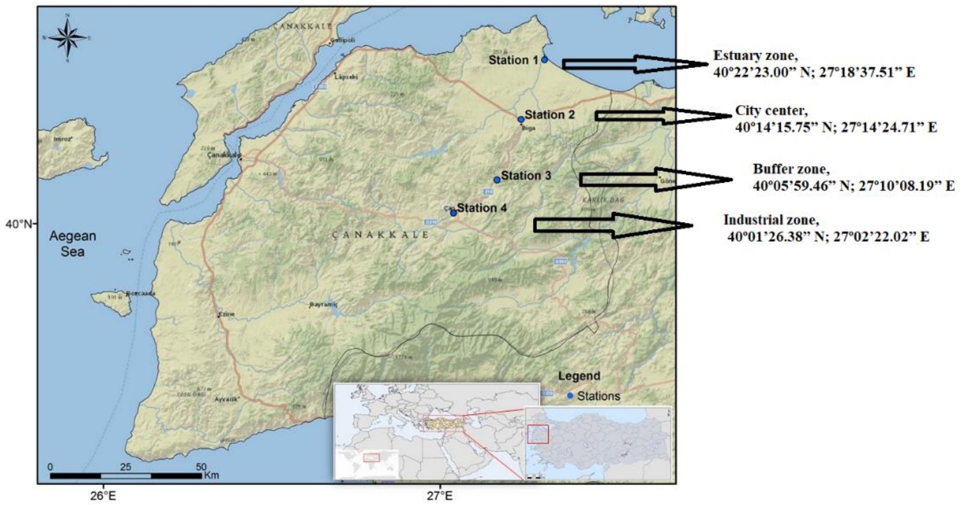

Figure 1. Map of the Biga Stream Showing Four Sampling Stations

Sampling for water parameters were carried out in the four sites at monthly intervals between Oct 2013 – Sep 2014, covering dry and rainy seasons. The collected water samples were analyzed for physicochemical parameters [temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), biological oxygen demand (BOD)] and bacteriological parameters [heterotrophic plate count (HPC: +4 ºC/35 ºC), total coliform (TC), faecal coliform (FC), faecal streptococci (FS)] by following the standard methods of American Health Association (1988) in Table 1.

Table 1. Water quality parameters, units, and analytical methods used for analysis of the Biga stream

Parameters	Unit	Analytical Methods	Instruments
Temperature	ºC	Instrumental	Hatche Lange pH meter
pH	pH unit	Instrumental	Hatche Lange pH meter
Dissolved oxygen	mg/L	Instrumental	Hatche Lange pH meter
Electrical conductivity	(µS/cm)	Instrumental	Hatche Lange pH meter
Biological oxygen demand	mg/L	Titrimetric (Winkler's)	Titration assembly and BOD incubator
Heterotrophic plate count (+4 ºC)	CFU/mL)	Microbiological	-
Heterotrophic plate count (35 ºC)	CFU/mL)	Microbiological	-
Total coliform	MPN/100 mL	Multiple tube technique	-
Faecal coliform	MPN/100 mL	Multiple tube technique	-
Faecal streptococci	MPN/100 mL	Multiple tube technique	-

Standard methods were used for Total viable mesophyll counts (PCA) and isolation Enterobacteriaceae (Mac Conkey agar), *Vibrio* sp. (Thiosulfate Citrate Bile Salts Sucrose (TCBS) Agar), *Aeromonas* sp. (Glutamate Starch Phenol Red Agar) and *Plesiomonas shigelloides* (Inositol Brilliant Green Bile Agar). Plates were incubated at 25 – 30 ºC and examined after 24 - 48 hours (Murray, 1999). Isolated colonies were identified by Gram and biochemical reactions (Hayashi, 2004). For obtained isolates, verification tests were performed according to Microgen ID-A panel-Gram negative (MID-64).

2.2. Statistical procedures

A descriptive statistics (mean, median, mode, standard deviation, variance, minimum, and maximum), MANOVA and distribution graphs were achieved with IBM SPSS Statistics 230.

3. Results and Discuccion

Data for physicochemical and microbiological parameters of water samples were presented as mean values and analyzed using descriptive analysis (Table 2).

Table 2. Descripitives statistics of physicochemical and microbiological parameters of Biga stream (Oct 2013 to Sep 2014)

Parameters	N	Minimum	Maximum	Mean	Std. Deviation
T	48	7.0	28.8	18.329	6.4777
DO	48	5.3	21.7	9.106	3.2354
BOD_5	48	1.3	18.5	7.911	3.9690
pH	48	7.4	9.5	8.569	0.3528
EC	48	250.0	2150.0	1138.917	367.5781
HPC (+4 ºC)	48	0	96000.0	9845.833	14107.5800
HPC (+35 ºC)	48	0	2820000.0	290876.042	695154.2835
TC	48	0	110000.0	19539.583	33468.6944
FC	48	0	110000.0	26543.750	41459.0026
FS	48	0	110000.0	13010.417	30617.5533
Valid N (listwise)	48				

T: Temperature, DO: Dissolved oxygen, BOD_5: Biological oxygen demand, pH, EC:Electrical conductivity, HPC (+4 ºC): Heterotrophic psychrophilic plate count, HPC (+35 ºC): Heterotrophic mesophyll plate count, TC: Total coliform, FC: Faecal coliform, FS: Faecal streptococci

Table 3 was given some water quality parameters which were taken from Official Gazette (1988) to compare acquired data with inland standards. According to Official Gazette (1988), water quality of inland waters is classified into four groups as: high quality waters (Class 1), moderate quality waters (Class 2), polluted waters (Class 3), and highly polluted waters (Class 4).

Table 3. Limit values of some parameters according to inland water quality classification (Anonymous, 1988)

Parameter	Water quality categories			
	1: High quality waters	2: Moderate quality waters	3: Polluted waters	4: Highly polluted waters
T	25	25	30	>30
DO	8	6-8	3-6	3
BOD_5	4	4-8	20	>20
pH	6.5-8.5	6.5-8.5	6.0-9.0	6.0-9.0 except
EC	0-250	250-750	750-2250	2250-5000
HPC (+4 ºC)	n/a	n/a	n/a	n/a
HPC (+35 ºC)	n/a	n/a	n/a	n/a
TC	100	100 - 20000	20000 -100000	>100000
FC	10	10-200	200-2000	>2000
FS	n/a	n/a	n/a	n/a

n/a: not available

Temperature of water may not be as important because of the wide range of temperature tolerance in aquatic life, but in polluted water, temperature can have profound effects on dissolved oxygen (DO) and biochemical oxygen demand (BOD5) (Hacioglu and Dulger, 2009). In Biga Stream temperature average was seen in limit inland water quality parameters. Similar explanations are given by (Hacioglu and Dulger, 2009; Yayintas et al., 2007b) to explain temperature values for Biga stream.

DO content is one of the most important factors in stream health. Its deficiency directly affects the ecosystem of a river due to bioaccumulation and bio magnifications. The oxygen content in water samples depends on a number of physical, chemical, biological and microbiological processes. DO values also show lateral spatial and seasonal changes depending on industrial, human and thermal activity (APHA, 1998). Low DO concentrations (< 3 mg/L) in fresh water aquatics systems indicate high pollution level of the waters and cause negative effects on life in this system (Yayıntas et al., 2007b). In our study we found that it is seen that waters of Biga Stream to Class 1, for parameter of dissolved oxygen based on results of comparison of data with WPCR.

BOD5 is the most important parameters used to assess the quality of water regarding organic matter present in both suspended and dissolved form. Monthly variations of BOD5 varied between 1.3 and 18.5 mg/L and the mean BOD5 is 7.911. This values are very good for water quality so comparison of data of BOD5 and it seen that waters of Biga Stream belonged to Class 2.

pH of natural waters is governed by the carbonate – bicarbonate - carbon dioxide equilibrium. pH is an important factor that determines the suitability of water for various purposes, including toxicity to animals and plants. Slightly alkaline pH is preferable in waters, as heavy metals are removed as carbonate or bicarbonate precipitates. Heavy metals are not as toxic to aquatic life at alkaline pH, as they are present mostly in the unavailable form (Hacioglu and Dulger, 2009). In the present study, pH was found exactly alkaline (7.4 – 9.5) with little variation heaving a mean of 8.569. Finally Biga Stream is belonged to Class 2-3 for parameter of pH.

The mean EC is 1138.917 µS/cm and Biga Stream is belonged to Class 3 for parameter of EC. This status may be evidence that exposure to chemicals and high ionic charge of the Biga stream. EC is a useful indicator of total dissolved solids (TDS) because the conduction of current in an electrolyte solution is primarily dependent on the concentration of ionic species. The relationship between EC and TDS is complex depending on the chemical composition and ionic strength (Hayashi, 2004).

Elevated levels of heterotrophs are a general indication of microbial regrowth within the distribution system and a decline in overall water quality. Most heterotrophs are not a health risk, but they may cause taste and odor problems. Some heterotrophs, however, are opportunistic pathogens, such as Klebsiella, Legionella, Pseudomonas and Staphylococcus, and increases in heterotrophic bacterial levels may indicate conditions that are favorable to the growth of these pathogenic organisms (Stabili and Cavallo, 2004). HPC (+4 oC) and HPC (+35 oC) varies between 0 - 96x103 and 0 – 282 x104 cfu/mL, respectively. There are no limit values of some parameters according to inland water quality classification. HPC (+35 oC) densities is quite higher than HPC (+4 oC) with the intensity of both bacterial groups being high. Because of heterotrophic bacteria not only function as decomposers, but also channel dissolved organic substrates and inorganic nutrients into higher trophic levels through the microbial food web (Stabili and Cavallo, 2004), high intensity of both bacterial groups in Biga stream is very important outcome.

The TC, FC and FE bacteria tests are a primary indicator of potability that is suitability for consumption. These tests measure the concentration of total, faecal coliform and faecal streptococci associated with the possible presence of disease causing organisms (Shar et al., 2010). In the present study the means of TC, FC and FE are 20x103 MPN/100 mL, 27 x103 MPN/100 mL, 13x103 MPN/100 mL, respectively. Based on results of comparison of data with WPCR, it seen that waters of Saricay stream for TC and FC are belonged to class 2, class 4, respectively. Results which were found in the present investigation had shown similarity previous studies (Cakir, 2004; Hacioglu and Dulger, 2010). Also, there is no data about FS in WPCR. But, it appears from our results that the impact of all these factors means together contribute to the hierarchy of abundance FC > TC > FS. One possible explanation for the consistently higher rate of FC standard failures is that FC survives longer in the marine environment than TC or FS (Noble et al., 2003). But our findings suggest that this situation is different in fresh waters. FC/FS ratio is widely used to determine the origin of contamination. For human faecal contamination, FC/FS > 4, whereas with animal faecal contamination the FC/FE < 0.7 (Djuikom et al., 2008). In this study, FC/FE indicates that pollution is both human and animal origin. These findings proved that the role of human in contributing significantly to faecal contamination of Biga stream.

Table 4 provides the correlation matrix of the water quality parameters. When relations between parameters were examined, there was a negative correlations between T and DO ($r = -0.316$, $p = 0.029$), and T and FC values ($r = -0.395$, $p = 0.005$). The inverse relationship between temperature and dissolved oxygen is a natural process in water (Solanki et al., 2010), because warm water easily becomes saturated with oxygen and thus holds less DO (Bhat et al., 2014). There was a positive correlations between DO and pH ($r = 0.304$, $p = 0.036$), T and HPC (+4 oC) ($r = 0.303$, $p = 0.037$), TC and FC ($r = 0.646$, $p = 0.000$), TC and FS ($r = 0.676$, $p = 0.000$), FC and FC values ($r = 0,493$, $p = 0.000$). Numerous factors affect bacteria concentrations in the fresh water systems. Land use, the chemical and physical properties of stream water, seasonality, and reservoirs are all factors that can affect the concentration of bacteria. Seasonal changes in water temperature can either promote or inhibit bacteria growth (Solanki et al., 2010). Our findings about correlation between physical and microbiological parameters support these literature knowledges

Table 4. Correlation coefficient matrix for physicochemical and microbiological parameters in Biga stream

Correlations[c]											
Parameters		**T**	**DO**	**BOD**	**pH**	**EC**	**HPC (+4 °C)**	**HPC (+35°C)**	**TC**	**FC**	**FS**
T	Correlation	1.000	**-0.316***	-0.024	0.270	0.239	**0.303***	-0.131	-0.101	**-0.395***	-0.253
	Sig. (2-tailed)	.	0.029	0.873	0.064	0.102	0.037	0.376	0.494	0.005	0.082
DO	Correlation	-0.316*	1.000	0.204	**0.304***	-0.202	-0.268	0.089	0.004	-0.110	0.206
	Sig. (2-tailed)	0.029	.	0.165	0.036	0.168	0.066	0.548	0.979	0.458	0.160
BOD	Correlation	-0.024	0.204	1.000	-0.100	0.197	0.149	-0.227	-0.146	-0.231	-0.051
	Sig. (2-tailed)	0.873	0.165	.	0.500	0.180	0.313	0.121	0.323	0.115	0.733
pH	Correlation	0.270	0.304*	-0.100	1.000	0.002	-0.060	0.013	0.161	-0.079	0.132
	Sig. (2-tailed)	0.064	0.036	0.500	.	0.989	0.684	0.928	0.274	0.593	0.372
EC	Correlation	0.239	-0.202	0.197	0.002	1.000	0.212	0.183	-0.212	-0.195	-0.035
	Sig. (2-tailed)	0.102	0.168	0.180	0.989	.	0.148	0.213	0.147	0.185	0.816
HPC (+4 °C)	Correlation	0.303*	-0.268	0.149	-0.060	0.212	1.000	-0.239	-0.104	-0.058	-0.213
	Sig. (2-tailed)	0.037	0.066	0.313	0.684	0.148	.	0.102	0.480	0.696	0.145
HPC (+ 35 °C)	Correlation	-0.131	0.089	-0.227	0.013	0.183	-0.239	1.000	0.226	0.210	0.283
	Sig. (2-tailed)	0.376	0.548	0.121	0.928	0.213	0.102	.	0.123	0.151	0.051
TC	Correlation	-0.101	0.004	-0.146	0.161	-0.212	-0.104	0.226	1.000	**0.646****	**0.676****
	Sig. (2-tailed)	0.494	0.979	0.323	0.274	0.147	0.480	0.123	.	0.000	0.000
FC	Correlation	-0.395**	-0.110	-0.231	-0.079	-0.195	-0.058	0.210	0.646**	1.000	**0.493****
	Sig. (2-tailed)	0.005	0.458	0.115	0.593	0.185	0.696	0.151	0.000	.	0.000
FS	Correlation	-0.253	0.206	-0.051	0.132	-0.035	-0.213	0.283	0.676**	0.493**	1.000
	Sig. (2-tailed)	0.082	0.160	0.733	0.372	0.816	0.145	0.051	0.000	0.000	.

*Correlation is significant at the 0.05 level (two-tailed);**correlation is significant at the 0.01 level (two-tailed)

Prior to investigating the seasonal effect on water quality parameters, we divided the whole observations period into four fixed seasons: spring (March, April, and May), summer (June, July, and August autumn (September, October, and November), and winter (December, January, and February) and use Multivariate Analysis of Variance (MANOVA) to compare spatial-temporal variations on physicochemical and microbiological parameters, respectively (Table 5-6). Function of MANOVA is comparison of dependent variable means across multiple groups Tanty et al., 2014). There was a statistically significant difference ($p < 0.05$) in terms of T, DO and pH between seasons, although there was no significant difference between the stations (Table 5). The distribution graph of T, DO and pH values, which show significant differences between the seasons, was given to Figure 2.

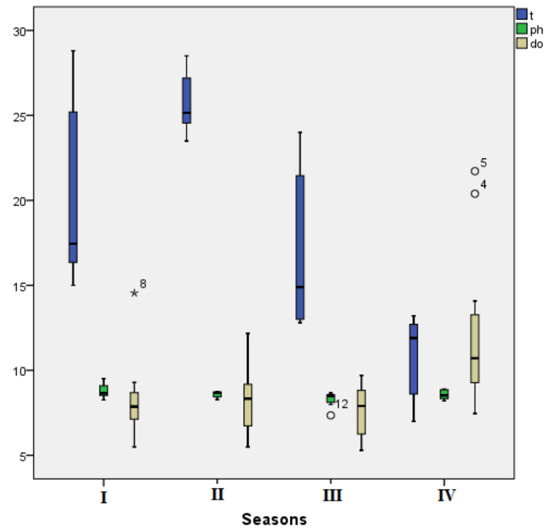

Figure 2. The Boxplot graph of T, DO and pH Values According to Seasons
I: Spring, II: Summer, III Autumn, IV: Winter.

Table 5. MANOVA test for physicochemical parameters in Biga stream

Tests of Between-Subjects Effects							
Source	**Dependent Variable**	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Stations	**T**	8.234	3	2.745	0.160	0.922	0.015
	DO	43.343	3	14.448	2.355	0.090	0.181
	BOD	80.401	3	26.800	1.881	0.153	0.150
	pH	0.163	3	0.054	0.454	0.716	0.041
	EC	251500.500	3	83833.500	0.556	0.648	0.050
Season	**T**	1406.978	3	468.993	27.405	**0.000**	0.720
	DO	154.711	3	51.570	8.407	**0.000**	0.441
	BOD	114.212	3	38.071	2.672	0.064	0.200
	pH	1.356	3	0.452	3.786	**0.020**	0.262
	EC	598081.333	3	199360.444	1.322	0.284	0.110
Stations * Season	**T**	9.328	9	1.036	0.061	1.000	0.017
	DO	97.638	9	10.849	1.768	0.114	0.332
	BOD	89.878	9	9.986	0.701	0.703	0.165
	pH	0.513	9	0.057	0.478	0.879	0.118
	EC	674242.500	9	74915.833	0.497	0.866	0.123

There was a statistically significant difference ($p < 0.05$) between stations and seasons in terms of TC, FC and FS; HPC (+ 35 ºC) and FS, respectively (Table 6). The distribution graph of TC, FC and FS values, which show significant differences between the stations was given to Figure 3. The graphs of HPC (+ 35 ºC) and FS values according to seasons were given to Figure 4.

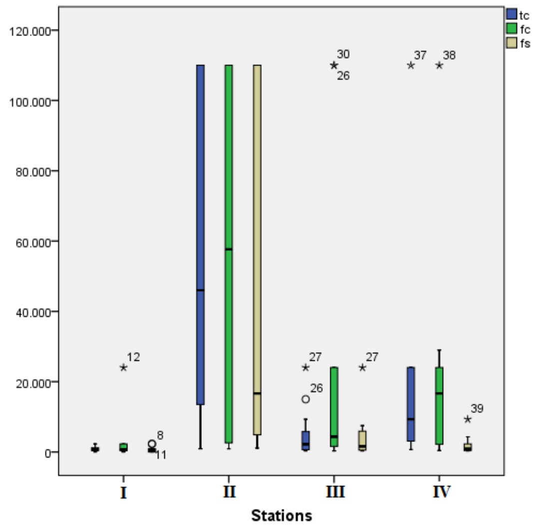

Figure 3. The Boxplot graph of TC, FC and FS Values According to Stations
I: 1. Station, II: 2. Station, III: 3. Stations, IV: 4. Station.

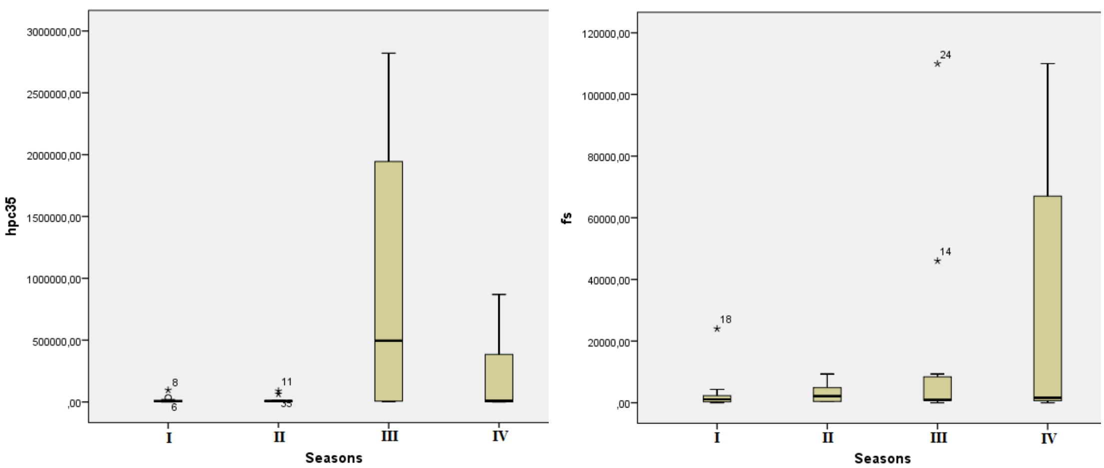

Figure 4. The Boxplot graph of HPC (+ 35 ºC) and FS Values According to Seasons
I: Spring, II: Summer, III Autumn, IV: Winter.

Table 6. MANOVA test for microbiological parameters in Biga stream

Tests of Between-Subjects Effects							
Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Stations	**HPC (+4 ^oC)**	1424444166.667	3	474814722.222	2.657	0.065	0.199
	HPC (+ 35 ^oC)	860004348389.582	3	286668116129.861	0.729	0.542	0.064
	TC	20351965625.000	3	6783988541.667	9.520	**0.000**	0.472
	FC	17741477291.667	3	5913825763.889	3.615	**0.024**	0.253
	FS	16504992291.667	3	5501664097.222	29.060	**0.000**	0.731
Season	**HPC (+4 ^oC)**	701957500.000	3	233985833.333	1.309	0.288	0.109
	HPC (+ 35 ^oC)	7091673042656.252	3	2363891014218.751	6.008	**0.002**	0.360
	TC	3942872291.667	3	1314290763.889	1.844	0.159	0.147
	FC	6376268958.333	3	2125422986.111	1.299	0.292	0.109
	FS	6208298958.333	3	2069432986.111	10.931	**0.000**	0.506

The absence of seasonal statistically significant difference due to seasonal differences (especially temperature variations in seasons) in physical and microbiological parameters is a possible outcome. However, the difference between stations observed in microbiological parameters reveals that the introduction of anthropogenic pollutants into the aquaculture should be investigated individually and the precautions should be taken accordingly.
Diversity of culturable heterotrophic aerobic bacteria isolated from Biga stream Monthly microbiological parameters were shown in Table 7.

Table 7. Diversity of culturable heterotrophic aerobic bacteria isolated from Biga stream

Phylum/Class	Familia	Species	Stations I (n=36)	II (n=48)	III (n=38)	IV (n=39)
Proteobacteria/ γ Proteobacteria	Enterobacteriaceae	Escherichia coli	3	7	8	5
		E.coli-inactive	2	-	-	1
		E.gergoviae	-	2	-	2
		Klebsiella pneumoniae	-	-	1	2
		K.oxytoca	-	2	-	2
		Citrobacter diversus	-	-	-	1
		Serratia liquefaciens	1	-	-	1
		S.rubidaea	-	1	-	-
		Salmonella arizonae	-	-	-	1
	Moraxellaceae	Acinetobacter baumanii	-	-	-	1
		Moraxella sp.	-	1	-	-
	Shewanellaceae	Shewanella putrefaciens	-	2	-	-
	Pasteurellaceae	Pasteurella multocida	-	4	4	2
		Actinobacillus sp.	-	1	-	-
	Aeromonadaceae	Aeromonas hydrophila	18	17	20	10
		A.caviae	1	1	-	5
	Pseudomonadaceae	Pseudomonas fluerescens	1	-	-	-
		P.fluerescens 25^{0}C	1	1	-	1
		Ps. aeruginosa	6	3	1	-
Proteobacteria/β Proteobacteria	Burkholderiaceae	Burkholderia pseudomallei	3	5	3	3
		B.cepacia	-	-	-	1
Bacteroidetes/ Flavobacteria	Flavobacteriaceae	E.meningosepticum	-	1	-	-
		Total	36	48	38	39

A total of 161 colonies were isolated from the Biga stream (Table 7). During the study period, 3 bacterial classes were recorded: Gammaproteobacteria (88,81%), Betaproteobacteria (9,31%), Bacteroidetes/ Flavobacteria (0,62%). In this study, the presences of 22 culturable heterotrophic bacteria species belonging to 8 different families from the Biga stream were reported for the first time. Although these bacteria had not previously been reported from these areas, they may be ubiquitous in aquatic environments. Gamma Proteobacteria was the most common group in terms of species number in comparison to the other taxonomic groups in the coastal areas. The species belonging to Aeromonadaceae family was the most common taxonomic group in the coastal areas of Biga stream (Figure 5). Enterobacteriaceae family was the second most common group. The genus most frequently cultured from all four stations was *Aeromonas*, which bacterium is widespread in aquatic environments and its presence not unsurprising (Belt et al., 2007). *E. coli* was the second most-prevalent species encountered, and again, its presence was not unexpected.

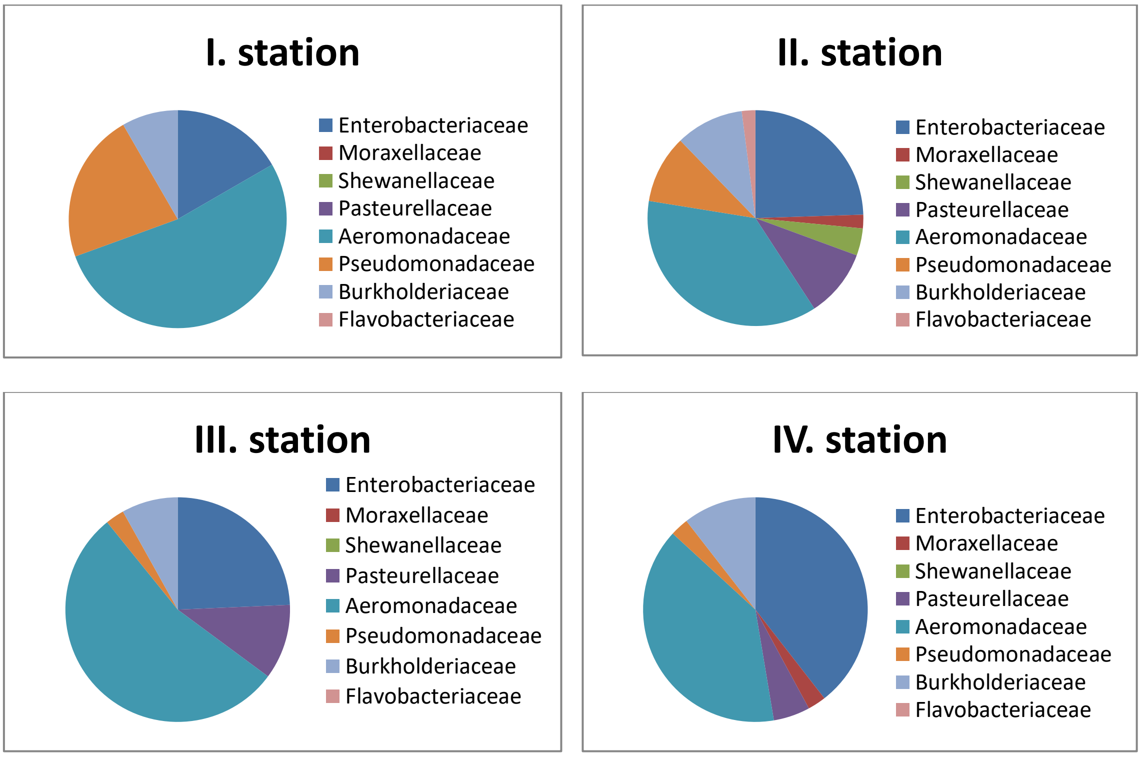

Figure 5. The Abundance of Culturable Bacteria Which were Isolated from Four Stations

The bacteriological quality of the Biga stream posed an increased risk of infectious disease transmission to the communities that were dependent on the stream. Several studies have isolated Enterobacteriaceae, Aeromonadaceae, Pseudomonadaceae etc. from freshwater samples. These bacteria have been documented to cause dermatitis, stomatitis, rhinitis, pneumonia, osteomyelitis, septicemic cutaneous ulcerative disease and septicemia (Belt et al., 2007). Our findings show that the presences of these microorganisms, which may be pathogens for humans, will be a risk for public health. Thus, the people who live near this areas, fishermen and aquarists should be more careful when being in contact with streams water.

4. Conclusions

Streams are vital and have important multi-usage components, such as functions of water in the body are cell life, chemical and metabolic reaction, transform of nutrients, body temperature regulation and elimination of waste and providing water resources for domestic, industrial and agricultural purposes. Therefore effective maintenance of water quality is required through appropriate measurements. The data obtained show that a large part of the Biga stream is located in the city center and that its environment is under great pressure due to industrial, anthropogenic and agricultural pollutants. Especially the high microbiological pollution values we have obtained in our findings suggest that this important freshwater source should be monitored for the determination of the sources of pollution and the removal of the pollutant sources from the point of view of public health.

Acknowledgments

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