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Full Length Research Paper

Monthly variation of some physico-chemical and microbiological parameters in Biga Stream (Biga, Canakkale, Turkey)

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Water samples were collected from three different sites of the Biga Stream (Canakkale, Turkey) in the months of October 2007 – September 2008 for the analyzing of some physico-chemical and microbiological parameters of the stream. In the present investigation, the mean average value (mean ± SD) of the stream temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD_5), pH, electrical conductivity (EC), total coliform (TC) and faecal coliform (FC) were noted as 15.533 ± 0.199°C, 8.332 ± 0.253 mg/L, 136.60 ± 2.51 mg/L, 7.5078 ± 0.0427, 869.93 ± 3.72 µS/cm, 39381 ± 7952 MPN/100 mL and 42500 ± 7072 MPN/100 mL, respectively. Based on results of comparison of data with WPCR, it is seen that waters of Biga Stream at the sites 1, 2 and 3 belonged to Class 4, for parameter BOD_5 and faecal coliform and belonged to Class 3 for parameter total coliform. We conclude that there is a great potential risk of infection of waters from the Biga Stream.

Key words: Biga Stream, biochemical oxygen demand, dissolved oxygen, total coliform, faecal coliform, physico-chemical and microbiological parameters.

INTRODUCTION

Lakes, rivers and streams have important multi - usage components, such as sources of drinking water, irrigation, fishery and energy production (Iscen et al., 2008). Water is a scarce and fading resource, and its management can have an impact on the flow and the biological quality of rivers and streams (Prat and Munné, 2000). In the recent past, expanding human population, industrialization, intensive agricultural practices and discharges of massive amount of wastewater into the river and stream have resulted in deterioration of water quality. The impact of these anthropogenic activities has been so extensive that the water bodies have lost their self-purification capacity to a large extent (Sood et al., 2008).

The quality of water is typically determined by monitoring microbial presence, especially faecal coliform bacteria (FC) and physico-chemical parameters (EPA, 1999). These parameters could be affected by external and internal factors. There is 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 physico-chemical parameters such as temperature, pH and dissolved oxygen (DO) 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).

Coliform bacteria are used as microbiologic indicators for water quality. Freedom from contamination with faecal matter is the most important parameter of water quality because human faecal matter is generally considered to be a greater risk to human health as it is more likely to contain human enteric pathogens (Scott et al., 2003). The use of bacteria as a water quality indicators specifies faecal contamination and thus can be used as a signal to determine why such contamination is present, how serious it is and what steps can be taken to eliminate it. The higher the level of indicator bacteria, the higher the level of faecal contamination and the greater will be the

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risks of water borne diseases (Pipes, 1981; Sood et al., 2008).

The microbiological and physico-chemical parameters of different fresh water systems (river, stream, ocean etc.) have been studied by various researchers (Bezuidehout et al., 2002; Servais et al., 2005; Dere et al., 2006; Moskovchenko et al., 2009). In addition, several investigators have worked on seasonal variations of heavy metal pollution with microbiological parameters of Biga Stream (Yayıntas et al., 2007a; Yayıntas et al., 2007b). However, there is no report pertaining to exploration of monthly variation physico-chemical and microbiological parameters in the Biga Stream system.

The primary aim of this study was to determine the microbial quality (total and faecal coliform counts) and some physico-chemical parameters of the water in the Biga Stream. The secondary aim of the study was to determine monthly changes in the bacterial population. These findings will reveal the effects of the rural population and industries situated along the river on the microbial population changes.

MATERIALS AND METHODS

Study area

The Biga (Kocabas) Sream is located in the southwest region of Marmara, latitude 40° 15' to 40° 27' N and longitude 27° 13' to 27° 28' E, in Canakkale, Turkey (Figure 1a). 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 m^3 s^{-1} (DSI, 2000). This water resource is used for agriculture as on irrigation water and drinking water for animals (such as cows, sheep and birds) (Yayıntas et al., 2007a). Description of sampling sites is written below.

Site 1: Out of the Cavus village that at a distance about 4 km from Biga center, was polluted by domestic, zoic and tanning factories waste.
Site 2: It is Biga county center which was polluted by urban, stone quarry and farm waste.
Site 3: Below of the Bakacak village that a distance about 4 km from Biga center, was polluted by waste of Can Thermic Power, Can Ceramic Fabric, domestic and zoic waste (Figure 1b).

Water quality analysis

Sampling for water quality parameters were carried out in the three study sites at monthly intervals between October 2007 and September 2008, covering dry and rainy seasons (Figure 1b). Standard methods (APHA, 1995) were used during collection, preservation and estimation of different parameters. Water temperature, pH, electrical conductivity (EC) and dissolved oxygen (DO) were estimated at the spot with Hatch- Lange trademark ecological kit. Rest of the parameters (biochemical oxygen demand (BOD_5), total and faecal coliform) were determined in the laboratory within three hours of collection.
All samples were collected in 2 litres sterile bottles, kept at 4°C and analyzed within 3 h for microbiological and BOD_5 analysis.

Microbiological quality was determined by the standard most probable number (MPN) method. In total coliform (TC) counts, after the necessary dilution was carried out in the water samples, 10 mL of the sample was put into three tubes each with double strength. One milliliter was put into each of first three single – strength tubes, and 0.1 mL sample was put into each one of the other three tubes, all containing Brilliant Green Lactose Bile Broth (BGLBB, Oxoid) medium. The tubes were incubated at 37°C for 24 – 48 h. During this period, the gas accumulation in Durham tubes was observed and The Most Probable Coliform Number was determined using the MPN index (Finstein, 1972; Collins and Lyne, 1987; Veissman and Hammer, 1993).

In the faecal coliform (FC) counts, the same process was followed as the total coliform (TC) counts, but the tubes were incubated at 44.5°C. The Most Probable Faecal Coliform Number was determined from MPN index considering the gas accumulation in Durham tubes (Finstein, 1972; Collins and Lyne, 1987; Veissman and Hammer, 1993).

For biochemical oxygen demand (BOD_5; mgL^{-1}) analysis, the samples were immediately brought into the laboratory to determine for BOD_5 by using Winkler method (APHA, 1995).

Statistical procedures

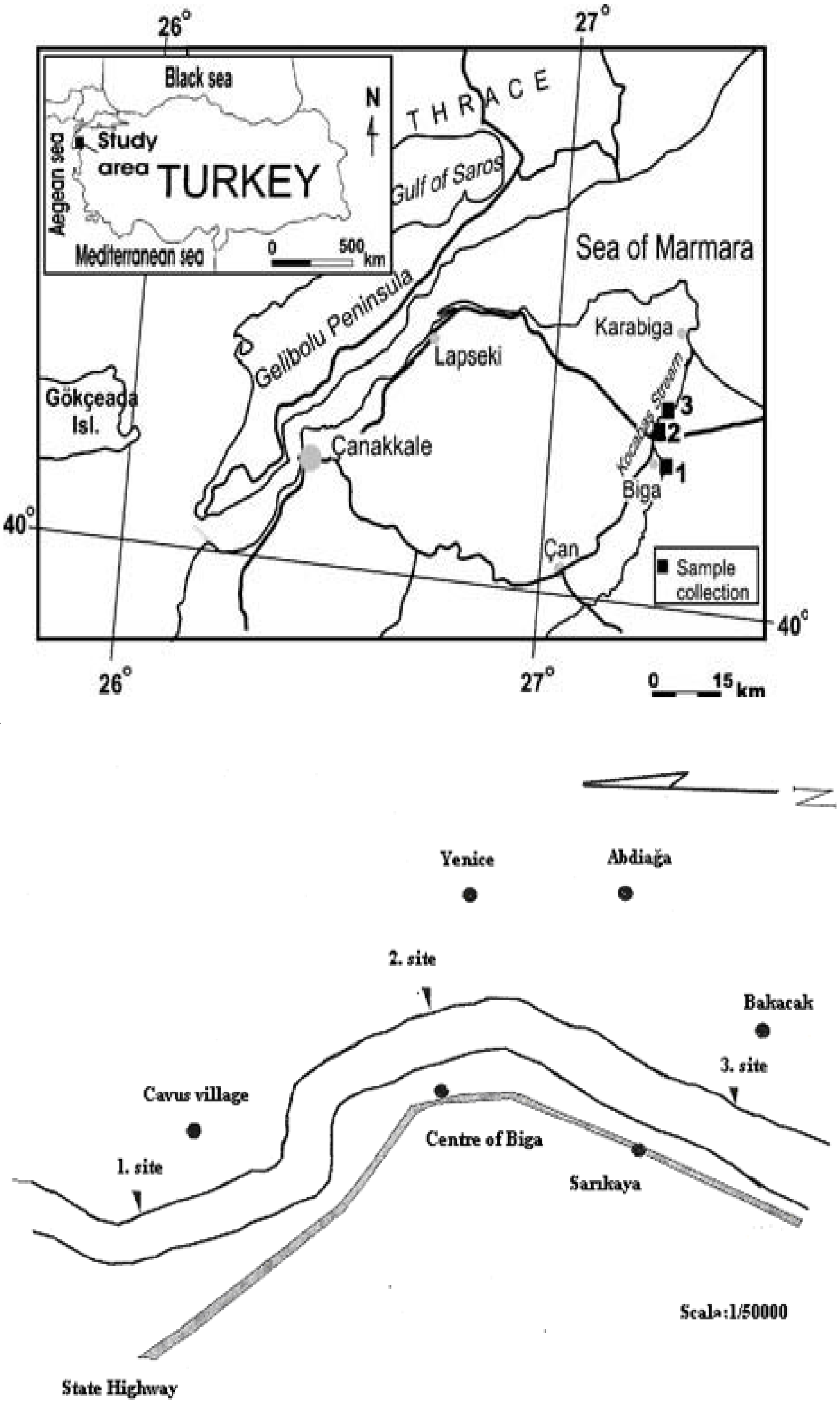
Mean and SE mean of microbiological and physico-chemical analysis data were used to present monthly values for these parameters. Statistical parameters of physico-chemical and microbiological analyses data were used to present the values of these water quality characteristics. Pearson's correlation coefficient (r) was used to show correlation between the all parameters data using the MINITAB Statistical Software 13.20. The Student's t-test was used to determine the statistical significance. Probability was set at $p < 0.05$.

RESULTS AND DISCUSSION

Monthly temperature, DO, BOD_5, pH, EC, TC, FC data from three sampling sites along the Biga Stream for the period October 2007 to September 2008 were shown in Table 1 and Table 2 is a summary of arithmetic mean of all parameters. Additionally, the monthly variations of physico-chemical properties were given in Figures 2 - 8. Table 3, a summary of correlation coefficients between various parameters are indicated in Biga Stream.

Table 4 was given some water quality parameters which were taken from Official Gazette (1988) to compare acquired data with inland standards. According to Turkish legislation [Water Pollution Control Regulation (WPCR)] 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).

The temperature varies between 3.8°C (January 2008, Site 3) and 26.6°C (July 2008, Site 1) in the stream. The mean temperature is 15.55 ± 2.47, 15.32 ± 2.37, 15.73 ± 2.31 in sites 1, 2, 3, respectively. 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 (BOD_5) (Ahipaty and Puttaiah, 2006). In three sites of Biga Stream temperature average was seen in limit inland water quality parameters. Similar explanation is given by Yayıntas et al. (2007b) to explain temperature values.



a

b

Figure 1. a. Location of Biga Stream in Turkey (Yayıntas et al., 2007a) b. Map of Biga stream indicating the sampling sites.

Based on results of comparison of data with WPCR, it is seen that waters of Biga Stream at the sites 1, 2, 3 belonged to Class 1, for parameter of temperature.

Monthly variations of DO varied between 4.95 mg/L (August 2008, Site 3) and 11.71 mg/L (January 2008, Site 3) in the stream. The mean DO is 8.837 ± 0.593, 8.112 ± 0.669, 8.048 ± 0.699 in sites 1, 2, 3, respectively. 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 biomagnifications. The oxygen content in water samples depends on a number of physical, chemical, biological and microbiological pro-

Table 1. Monthly variations of physico - chemical characteristics in the Biga Stream.

Sampling site	Parameters						
Site 1	**Temperature (^{o}C)**	**Dissolved oxygen (mg/L)**	**BOD_5 (mg/L)**	**pH**	**Electrical conductivity (µS/cm)**	**Total coliform (MPN/100 mL)**	**Faecal coliform (MPN/100 mL)**
Oct/07	15.1	6.02	45	7.65	1197	46×10^3	24×10^2
Nov/07	7.1	8.86	25	7.65	551	11×10^4	11×10^4
Dec/07	6.3	10.85	250	7.61	872	46×10^3	9×10^2
Jan/08	3.9	11.08	750	6.77	961	93×10^2	93×10^2
Feb/08	7.2	10.69	50	7.44	427	46×10^3	24×10^3
Mar/08	11.4	9.43	24,5	7.70	720	11×10^4	11×10^4
Apr/08	12.9	9.00	100	7.88	930	43×10^2	21×10^2
May/08	21.9	9.08	5,2	7.96	1017	43×10^2	21×10^2
Jun/08	23.6	5.18	75	7.63	1011	23×10^2	93×10^2
Jul/08	26.6	5.80	70	7.43	1008	23×10^2	23×10^2
Aug/08	25.2	10.15	100	7.77	857	11×10^4	11×10^4
Sep/08	25.4	9.90	85	7.55	855	23×10^2	23×10^2
Site 2							
Oct/07	15.4	7.01	20	7.65	1195	46×10^3	11×10^4
Nov/07	7.3	9.17	10	7.43	552	11×10^4	11×10^4
Dec/07	6.7	10.44	565	7.71	870	11×10^4	11×10^4
Jan/08	4.0	11.02	90	6.65	958	93×10^2	43×10^2
Feb/08	5.4	10.83	262	7.07	430	11×10^4	93×10^2
Mar/08	11.9	9.88	125	7.02	753	11×10^4	11×10^4
Apr/08	14.3	8.55	130	7.89	949	43×10^2	43×10^2
May/08	21.6	9.15	100	8.00	1065	43×10^2	23×10^2
Jun/08	23.3	5.32	85	7.68	1057	43×10^2	4×10^2
Jul/08	23.4	5.30	57	7.58	980	11×10^4	43×10^2
Aug/08	25.5	5.43	130	7.38	869	43×10^2	43×10^2
Sep/08	25.0	5.25	90	7.22	850	43×10^2	43×10^2
Site 3							
Oct/07	16.7	7.21	20	7.69	1177	15×10^3	46×10^3
Nov/07	9.4	8.40	35	7.65	551	11×10^4	11×10^4
Dec/07	6.6	10.88	135	7.68	858	46×10^3	20×10^2
Jan/08	3.8	11.71	250	7.19	961	93×10^2	9×10^2
Feb/08	6.7	11.00	260	7.04	423	46×10^3	9×10^2
Mar/08	11.7	9.28	204	7.05	752	36×10^2	11×10^4
Apr/08	14.4	8.62	125	7.90	918	43×10^2	11×10^4
May/08	21.8	8.47	83	7.89	1023	43×10^2	24×10^3
Jun/08	23.6	5.56	237	7.68	1029	93×10^2	24×10^3
Jul/08	23.8	5.50	100	7.48	980	23×10^2	11×10^4
Aug/08	25.0	4.95	125	7.41	862	24×10^3	11×10^4

cesses. DO values also show lateral spatial and seasonal changes depending on industrial, human and thermal activity (APHA, 1985). 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 between 4.95 mg/L to 11.71 mg/L values, this DO concentrations were high, so that can be by high flow rate of stream. Based on results of comparison of data with WPCR, it is seen that waters of Biga Stream at the sites 1, 2, 3 belonged to Class 1, for parameter of dissolved oxygen.

BOD_5 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 BOD_5 varied between 5.2 (May 08, Site 1) and 262 mg/L (Feb 08, Site 2) and the mean BOD_5 is 131.6 ± 59.1, 138.7 ± 43.0 and 139.5 ± 23.4 in sites 1, 2,

Table 2. Values of physicochemical and microbiological parameters (Mean ± SD) of Biga Stream.

Parameter	Site			
	1	2	3	Average
Temperature (°C)	15.55 ± 2.47	15.32 ± 2.37	15.73 ± 2.31	15.533 ± 0.199
Dissolved oxygen (mg/L)	8.837 ± 0.593	8.112 ± 0.669	8.048 ± 0.699	8.332 ± 0.253
BOD_5 (mg/L)	131.6 ± 59.1	138.7 ± 43.0	139.5 ± 23.4	136.60 ± 2.51
pH	7.5867 ± 0.0869	7.440 ± 0,113	7.4967 ±0.0868	7.5078 ± 0.0427
Electrical conductivity (µS/cm)	867.2 ± 61.6	877.3 ± 62.3	865.3 ± 60.4	869.93 ± 3.72
Total coliform (MPN/100 mL)	41067 ± 13070	52233 ±15089	24842 ± 8932	39381 ± 7952
Faecal coliform (MPN/100 mL)	32058 ± 13691	39458 ±15051	55983 ± 14233	42500 ± 7072

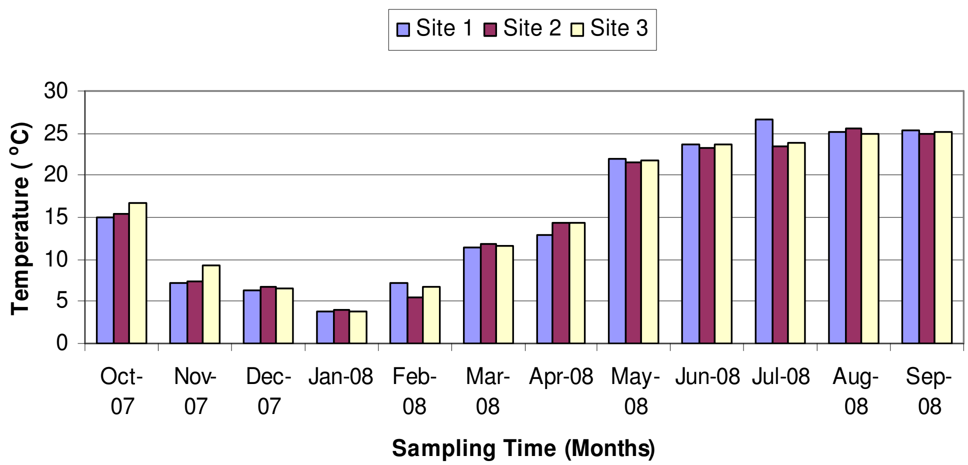


Figure 2. Temperature variation of Biga Stream.

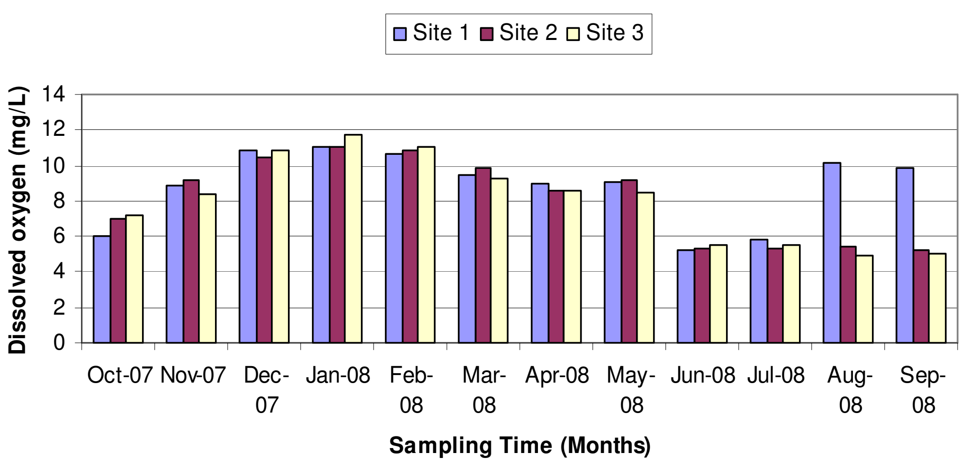


Figure 3. Dissolved oxygen variation of Biga Stream.

3, respectively. This values are very high for water quality so comparison of data of BOD_5. It seen that waters of Biga Stream at the sites 1, 2, 3 belonged to Class 4.

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 (Ahipaty and Puttaiah, 2006). In the present study,

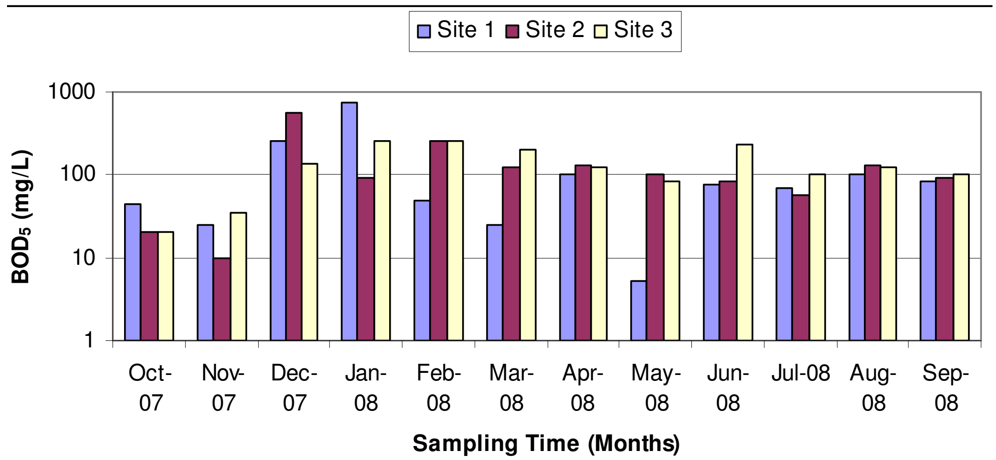


Figure 4. BOD_5 variation of Biga Stream.

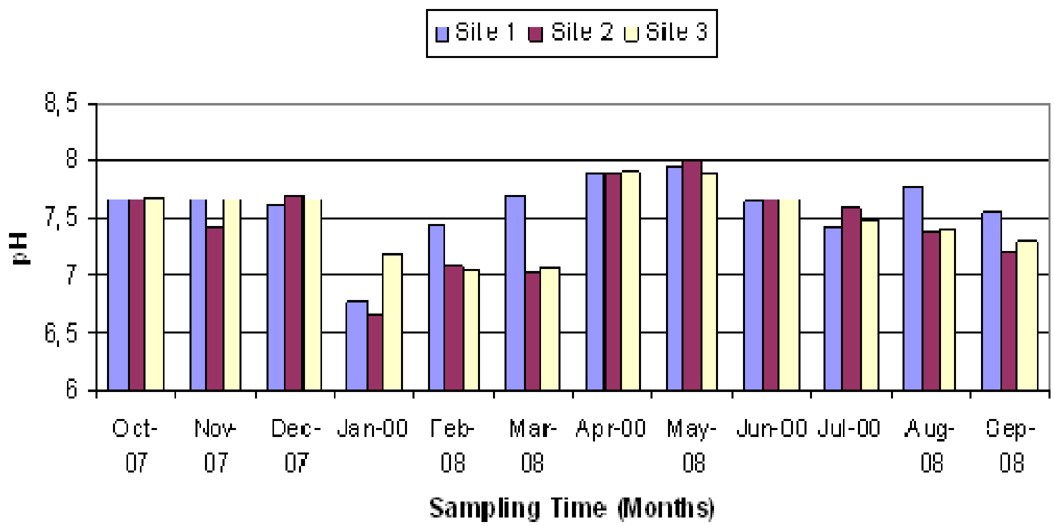


Figure 5. pH variation of Biga Stream.

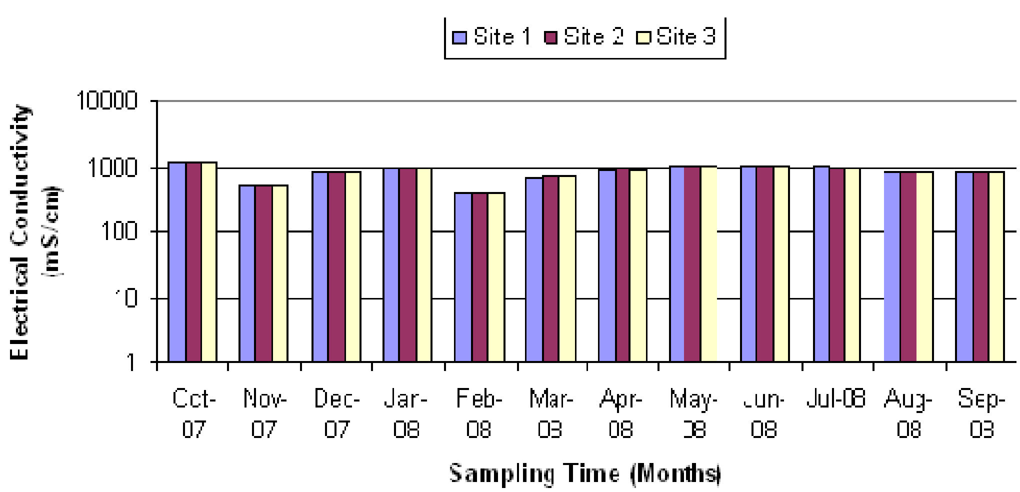


Figure 6. Electrical conductivity variation of Biga Stream.

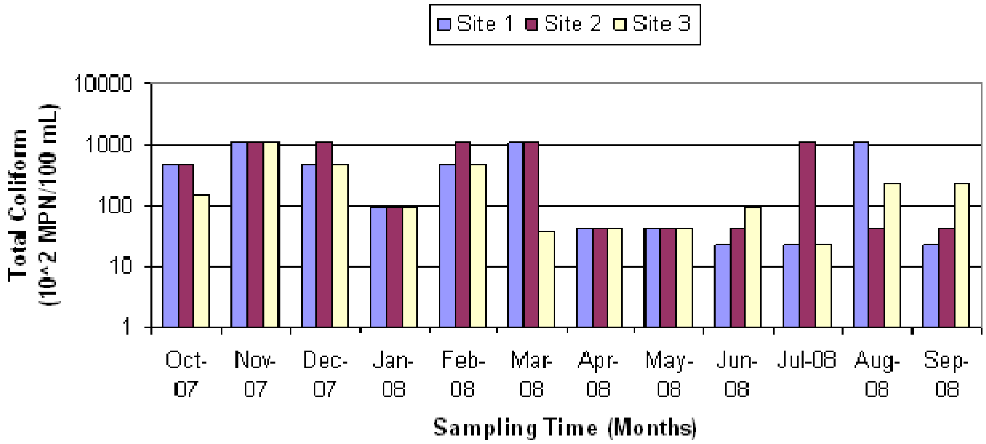


Figure 7. Total coliform variation of Biga Stream.

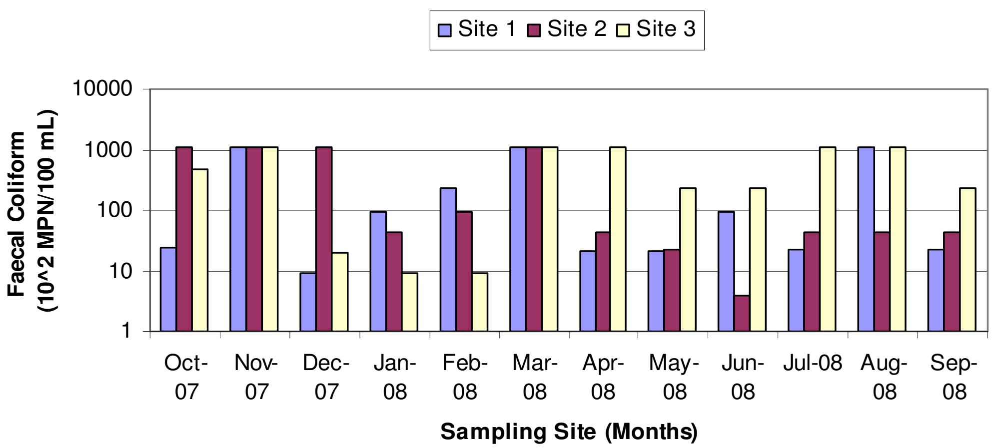


Figure 8. Faecal coliform of variation of Biga Stream

pH values in the water samples in Biga Stream ranged from 6.65 (Jan 08, Site 2) to 8.00 (May 08, Site 2). The mean pH is 7.5867 ± 0.0869, 7.440 ± 0.113 and 7.4967 ± 0.0868 in sites 1, 2, 3, respectively. Finally pH was found in alkaline pH in all sites except Jan 08, Site 1. Based on results of comparison of data with WPCR, it is seen that waters of Biga Stream at the sites 1, 2, 3 belonged to Class 1, for parameter of pH.

Electrical conductivity (EC) varies between 423 µS/cm (Feb 08, Site 3) and 1197 µS/cm (Oct 07, Site 1) in the Biga Stream. The mean EC is 867.2 ± 61.6, 877.3 ± 62.3 and 865.3 ± 60.4 in site 1, 2, 3, respectively.

Freshwaters polluted by faecal discharges from human and animals may transport a variety of human pathogenic micro - organisms (viruses, bacteria, protozoa). Because the detection of all waterborne faecal pathogens is very difficult, various indicators of faecal contamination are usually used to detect faecal pollution in natural waters. The abundance of these indicators is supposed to be correlated to the density of pathogenic micro - organisms from faecal origin and is thus an indication of the sanitary risk associated with the various water utilizations (bathing, shellfish harvesting and production of drinking water) (Servais et al., 2007). In the present study total coliform (TC) ranged from 23 x 10^2 11 x 10^4 MPN/100 mL (various months and sites), and faecal coliform (FC) ranged from 9 x 10^2 MPN/100 mL (Jan, Feb 08, Site 3) to 11 x 10^4 MPN/100 mL (various months and sites). The mean TC is 41067 ± 13070, 52233 ± 15089, 24842 ± 8932 and the mean FC is 32058 ± 13691, 39458 ± 15051, 55983 ± 14233 in sites 1, 2, 3, respectively. Based on results of comparison of data with WPCR, it is seen that waters of Biga Stream for total coliform and faecal coliform at the sites 1, 2, 3 belonged to class 3 and class 4, respectively. Results which were found in the present investigation had shown similarity with previous study (Yayıntas et al., 2007b). The bacteriological quality of the Biga Stream posed an increased risk of infectious disease transmission to the communities that were dependent on the stream.

Table 3. Correlation coefficients between the parameters in the stream of Biga.

Parameter	Temperature	Dissolved oxygen	BOD_5	pH	Electrical conductivity	Total coliform	Faecal coliform
Temperature	1	- 0.779*	- 0.394	0.367	0.468	- 0.380	- 0.107
Dissolved oxygen		1	0.379	- 0.222	- 0.432	0.279	0.013
BOD_5			1	- 0.395	- 0.050	- 0.014	- 0.086
pH				1	0.332	- 0.021	0.071
Electrical conductivity					1	- 0.539	- 0.239
Total coliform						1	0.501
Faecal coliform							1

* Correlation is significant at the 0,05 level.

Table 4. 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
Temperature (°C)	25	25	30	> 30
Dissolved oxygen (mg/L)	8	6 - 8	3 - 6	< 3
BOD_5 (mg/L)	4	4 - 8	8 - 20	> 20
pH	6.5 – 8.5	6.5 – 8.5	6.0 – 9.0	6.0 – 9.0 except
Electrical conductivity (µS/cm)	0 - 250	250 - 750	750 - 2250	2250 - 5000
Total coliform (MPN/100 mL)	100	100 - 20000	20000 -100000	> 100000
Faecal coliform (MPN/100 mL)	10	10 - 200	200 - 2000	> 2000

Yearly averages indicate a slight increasing trend at all the sites. But temperature showed significant negative correlation with dissolved oxygen which is indicated by asterisk in Table 3.

Water resources are sources of water that are useful or potentially useful to humans. Uses of water include agricultural, industrial, household, recreational and environmental activities. Virtually all of these human uses require fresh water. 97.5% of water on the earth is salt water, leaving only 2.5% as fresh water of which over two thirds is frozen in glaciers and polar ice caps. The remaining unfrozen fresh water is mainly found as groundwater, with only a small fraction present above ground or in the air. Fresh water is a renewable resource, yet the world's supply of clean, fresh water is steadily decreasing. Water demand already exceeds supply in many parts of the world, and as world population continues to rise at an unprecedented rate, many more areas are expected to experience this imbalance in the near future.

In the world there are a great deal investigations about fresh water quality (Gasim et al., 2007; O'Neal and Hollrah, 2007; Yillia et al., 2008). But there is not sufficient study about Biga Stream in Canakkale. Yayıntas et al. (2007b) investigated 'seasonal variation of some heavy metal pollution with environmental and microbiological parameters in sub-basin Kocabas (Biga) stream (Biga, Canakkale, Turkey) by ICP-AES'. Our findings showed similarity with this research.

In present study, most of the physico-chemical and microbiological parameters were below the permissible limits for Official Gazette (Water Pollution Control Regulation) (1988) standards for fresh water (Table 4). This can be attributed to the fact there are physical, chemical and biological processes which self - purify and restore streams, lakes, creeks, estuaries, rivers and oceans to their pristine conditions (Oketola et al., 2006), although, they are never restored back to their natural condition. Thus, some level of pollution can be observed around this point.

This study demonstrated that in the stream activities of people, farming irrigations, tannery waste and livestock significantly affected the microbial and physico-chemical water quality of the stream immediately of activities. So, pollution sources must be taken under control and cleaned waste waters by purification plants. Thus, water quality of stream can be improved in the future.

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