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Determination of water quality parameters from a waste treatment plant effluent (Balıkesir-Gönen).

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ABSTRACT

This study was conducted seasonally in four sampling stations in the discharge point of a slaughterhouse waste treatment system in Çerpeş Creek (Gönen-Balıkesir, Turkey) between August 2013 and March 2014. The aim of this study was to determine the physicochemical and biological effects of waste treatment's effluent to the discharge point. According to the analysis results, temperature changed between 9 and 27 °C among sampling stations that were being in the seasonal ranges. Conductivity ranged between and 578 and 3520 µs cm^{-1}. Total suspended solids (TSS) were measured between 1.2 and 104 mg L^{-1} and found to have the highest values in the first station which was the discharge point. Nutrients such as nitrite+nitrate (Nox), ammonium (NH_4), orthophosphate (PO_4-P) and silicate (SiO_2) varied among sampling stations having the values 0.0316 – 5.594 µM, 0.0001–0.0126 µM, 0.004–0.310 µM, and 2.26 – 5.02 µM, respectively. Greased oil was only analyzed during winter sampling, and found to be over the Water Pollution Control Regulation standards in all stations except the second station which was prior to the discharge point, with the values changing between 27.80 and 62.40 mg L^{-1}. Biological (BOD) and Chemical (COD) oxygen demand values were generally higher than the pronounced values in the Water Pollution Control Regulation standards ranging between 10.42 – 514.48 mg L^{-1}, and 19.51 – 1268.28 mg L^{-1}, respectively. Chlorophyll-a concentration changed between 0.078 and 13.79 µg L^{-1} among sampling stations, seasonally. In order to determine the microbial quality of the receiving water fecal and total coliform bacteria counts were also performed. Results showed that fecal and total coliform counts varied between 520-11000 cfu/100 ml and 1100-11000 cfu/100 ml, showing a high contamination in the system. Results of the environmental parameters indicated that the water quality of the study area changed seasonally among stations, and while the first station can be referred as the "fifth order quality" which can be considered as "very polluted", the second, third and fourth stations can be considered as "polluted" having "fourth order quality".

Introduction

When highly contaminated waste water caused by human activity is discharged into the receiving environment such as inland waters, seas and oceans; it does not only alter the physicochemical and biological structure of the environment significantly, but also causes alterations in the base structure of the water channel (Unlu et al. 2008). Amongst the main water contaminants are anionic detergents, heavy metals, pesticides, oils, petroleum products, microorganisms, organic and inorganic substances, dust, total suspended solids, and radioactivity (Ellis et al. 1989). The elements that effect water contamination can be basically classified as industrialization, urbanization, population increase, pesticides, and fertilizers and there has been various studies conducted on these issues. For example, Topal and Topal (2011) examined the effluent water of a waste treatment plant for an integrated meat processing plant in Elazig in order to identify the suitability of this water to the standards of discharge into the receiving system. For this purpose, they evaluated the parameters limited by Water Pollution Control Regulation (WPCR, 2012) standards and found that the results exceeded the values provided by WPCR (2012). Gurtekin and Unlu (2010) characterized and evaluated the waste water developed by Elazig Organized Industrial Zone and Animal Products Organized Industrial

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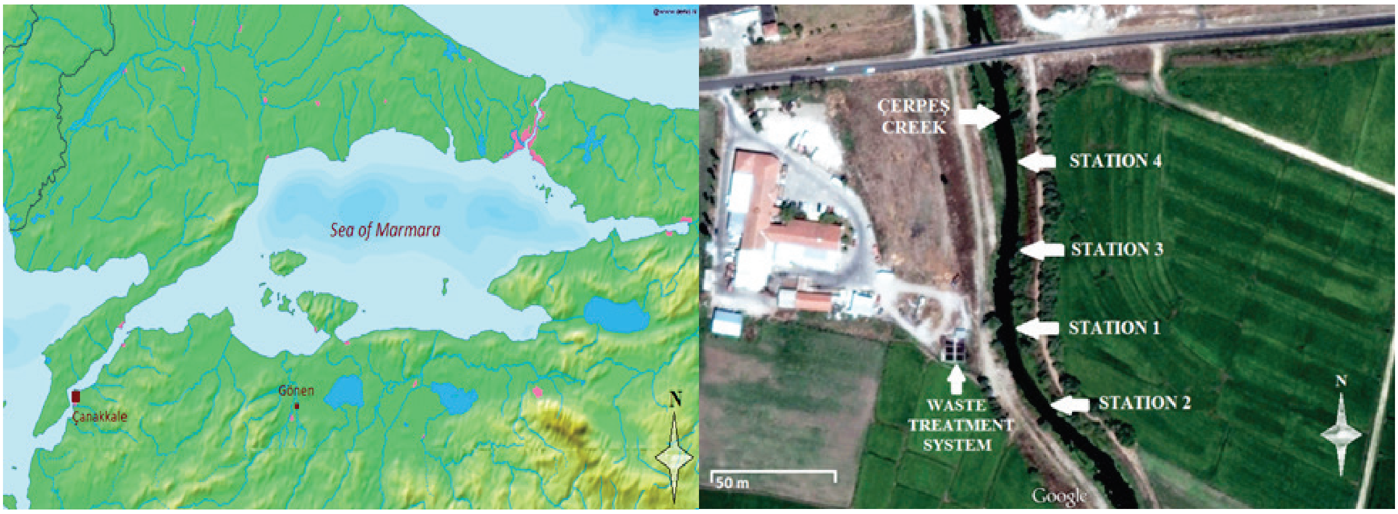

Figure 1. Location of the study area and the stations.

Zone with regard to treatment alternatives and found that the contamination concentration meets the standards of discharge into sewer that appear in WPCR (2012). Furthermore, some studies investigated the alteration values of domestic waste and some elements such as lead, iron, magnesium, copper, cadmium, calcium, sodium, potassium, etc. in inland waters. The purpose of this research was to identify the physicochemical and biological effects of waste water treatment plant on the discharge point. The fact that there were no studies conducted previously on the water quality in the region makes this study unique.

Material and methods

This study was conducted in an area over 150 m on Çerpeş Creek. 1st station was at the discharge point, 2nd station was located 50 m. prior to the discharge point, 3rd station was located 50 m. after the discharge point, and 4th station was located 100 m. after the discharge point (Figure 1, 2).

Figure 2. A general picture of the study area.

In order to determine the concentrations of nutrients such as NO_2, NO_3, NH_4, PO_4-P, SiO_2, which have a great importance in shaping the primary production, the water samples taken from the creek were analyzed spectrophotometrically depending on the biological and chemical techniques (Strickland and Parsons, 1972). Manometric BOD measurement device was used for BOD analysis. Open reflux method and standard methods for the examination of water and waste water were used for COD analysis (Eaton and Franson, 2005). In order to determine the water temperature, 0.1°C sensitive mercury thermometer was used. pH and conductivity values were immediately determined after sampling with WTW InoLab_IDS Multi 9310 and WTW InoLab pH/Cond 720 devices at Gönen Agricultural District Office.

Results

According to the analysis results temperature changed between 9 and 27°C among sampling stations that were being in the seasonal ranges. Conductivity ranged between 578 and 3520 µs cm^{-1}. Total suspended solids (TSS) were measured between 1.2 and 104 mg L^{-1} and found to have the highest values in the first station which was the discharge point (Table 1).

Nutrients such as nitrite+nitrate (Nox), ammonium (NH_4), orthophosphate (PO_4-P) and silicate (SiO_2) varied among sampling stations having the values 0.0316 – 5.594 µM, 0.0001–0.0126 µM, 0.004–0.310 µM, and 2.26 – 5.02 µM, respectively (Figure 3).

Greased oil was only analyzed during winter sampling, and found to be over the WPCR (2012) standards in all stations except the second station which was prior to the discharge point, with the values changing between 27.80 and 62.40 mg L^{-1}. Biological (BOD) and Chemical (COD) oxygen demand values were generally higher than the pronounced values in the WPCR (2012) standards ranging between 10.42 – 514.48 mg L^{-1}, and 19.51 – 1268.28 mg L^{-1}, respectively (Table 2).

Chlorophyll-a being an indicator of phytoplankton concentration in aquatic ecosystems changed between 0.078 and 13.79 µg L^{-1} among sampling stations, seasonally. Fecal and total coliform counts varied between 520-11000 cfu/100 ml and 1100-11000 cfu/100 ml, showing a high

Table 1. Temperature, Conductivity and Total Suspended Solids values for summer, fall, winter and spring in the study area.

	Variable	Summer	Fall	Winter	Spring	Seasonal Average
1st Station	Temperature (°C)	27	16	10	14	16.75
	Conductivity (µs/cm)	3520	3260	3210	2820	3202.50
	TSS (µg/lt)	15.60	104.00	31.00	48.57	49.79
2nd Station	Temperature (°C)	24	14	9	11	14.50
	Conductivity (µs/cm)	578	705	752	690	681.25
	TSS (µg/lt)	2.00	6.20	16.29	13.71	9.55
3rd Station	Temperature (°C)	24	14	9	11	14.50
	Conductivity (µs/cm)	578	798	747	694	704.25
	TSS (µg/lt)	1.60	5.80	10.67	11.60	7.42
4th Station.	Temperature (°C)	24	14	9	11	14.50
	Conductivity (µs/cm)	581	717	753	695	686.50
	TSS (µg/lt)	1.20	5.40	40.67	17.14	16.10
Average Between Stations	Temperature (°C)	24.75	14.50	9.25	11.75	
	Conductivity (µs/cm)	1314.25	1370.00	1365.50	1224.75	
	TSS (µg/lt)	5.10	30.35	24.65	22.76	

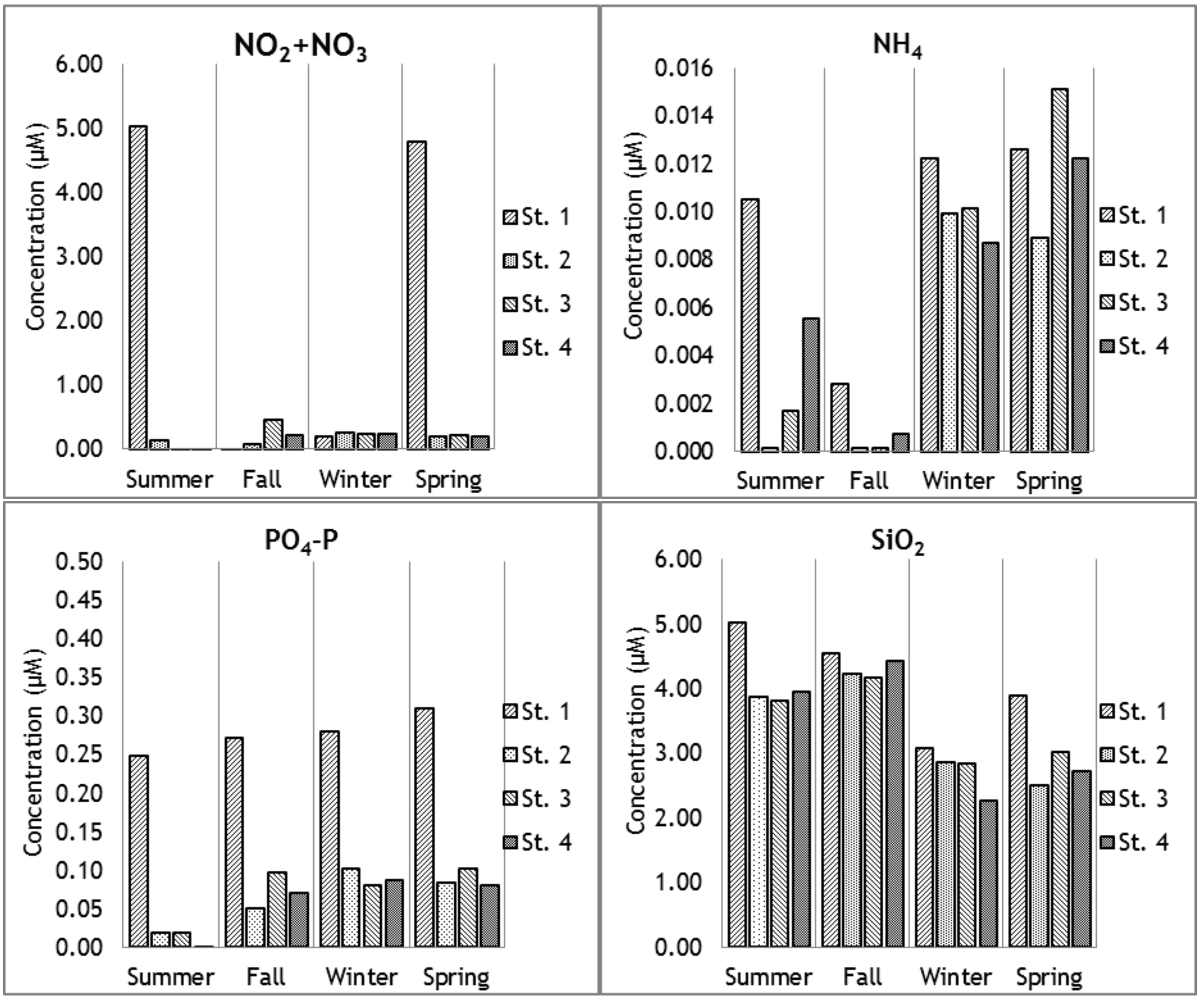

Figure 3. Concentration of dissolved Inorganic Nitrogen, Phosphate and Silicate distribution for summer, fall, winter and spring sampling.

Table 2. BOD and COD values for summer, fall, winter and spring samplings in the study area.

Stations	Summer	Fall	Winter	Spring	Seasonal Average
Biological Oxygen Demand (mg L^{-1})					
1st Station	514.48	194.5	52.39	162.83	231.05
2nd Station	10.42	122.5	25.22	43.26	50.35
3rd Station	15.63	122.5	19.78	43.26	50.29
4th Station	20.83	0	14.35	54.13	22.33
Av. Bet. St.	140.34	109.87	27.94	75.87	88.5
Chemical Oxygen Demand (mg L^{-1})					
1st Station	1268.28	404.1	86.47	225.77	496.15
2nd Station	19.51	266.11	45.64	63.8	98.77
3rd Station	24.39	246.4	33.63	68.71	93.28
4th Station	29.27	0	28.82	78.53	34.16
Av. Bet. St.	335.36	229.15	48.64	109.2	180.59

contamination in the system. Results of the environmental parameters indicated that the water quality of the study area changed seasonally among stations, and while the 1st station can be referred as the “fifth order quality” which can be considered as “very polluted”, the 2nd, 3rd and 4th stations can be considered as “polluted” having “fourth order quality”.

Discussion

During the study period water temperature values changed depending on the seasonal conditions due to the absence of difference in altitude between stations and closer proximity of each station. The average value of water temperature remained higher than the other stations in the 1st station meaning the waste water effluent of the slaughterhouse plant was warm.

It is known that the conductivity is proportional to the temperature and salinity (Barlas, 1995). Therefore, depending on the high temperature values of the 1st station the conductivity value was high in this station. Thus, except the 1st station all conductivity values were within the WPCR (2012) standards all through the study period (Table 1). This is meaningful since the region is a valuable irrigated agricultural area.

TSS affects photosynthesis by blocking the sunlight from reaching aquatic plants and causes the reduction of dissolved oxygen in the water. In addition, they affect the habitat of the benthic organisms negatively by sinking and covering up the area (Ünlü et al. 2008). When the amount of TSS in Çerpeş Creek compared with the discharges of slaughterhouse and studies conducted on some rivers, it appeared to be quite low (Danış, 1996; Gürtekin and Ünlü, 2010; Boyacıoğlu and Boyacıoğlu, 2004). Therefore, it can be suggested that low levels of TSS in the creek can be related with the high flow rates in the system.

The nitrogenous compounds most commonly found in natural waters are nitrite (NO_2^-), nitrate (NO_3^-) and ammonium (NH_4^+) and the quality of the water can be obtained by measuring these compounds (Mutlu et al., 2013). NO_2^- values in Çerpeş Creek were generally consistent with a previously conducted study on Sarıçay River, Canakkale (Odabaşı, 2005). When considering the average values in the terms of NO_2^- between the stations; 1st station can be referred as IV. order quality, 2nd, 3rd and 4th station can be referred as II. order quality according to WPCR (2012). The NO_3^- values in the study area observed to be quite low when compared with a study conducted by Polat and Olgun (2009) in an area which is close to the livestock holdings. When considering the average values in the terms of NO_3^- between the stations; all the stations can be referred as I. order quality according to WPCR (2012). NH_4^+ value varies depending on pH and temperature. Alkaline pH, high temperature and low dissolved oxygen values increase the toxicity of NH_3^+. Very small amounts of NH_4^+ nitrogen can be detected in clean and oxygen rich waters. In the domestic and industrial wastewaters the amount of NH_4^- increases. When considering the average values in the terms of NH_4^+ between the stations; all the stations can be referred as I. order quality according to WPCR (2012).

Total phosphorus concentration in natural waters depends on morphometry of the basin, the chemical content of region's geological structure, the presence and the amount of anthropogenic sources such as detergents and organic compounds and organic metabolism in the water body (Schwörbel, 1987). Phosphorus is a nutrient which is characterized as a growth limiting factor for primary production especially in the fresh water systems (Egemen and Sunlu, 2003) and PO_4-P amount is an indicator of waste water pollution (Höll, 1979). According to Horne and Goldman (1994) sewage treatment plant effluents usually contain 5-8 mg L^{-1} PO_4-P after treatment, therefore these waste waters have to be reprocessed to reduce the phosphate content. When the maximum values of PO_4-P were considered in our study area, the values have not exceeded the specified values given above.

The value of SiO_2 does not appear less than 10 mg L^{-1} in natural waters. At the same time, it is indicated that it has been detected as 60 mg L^{-1} even reaching to 100 mg L^{-1}

especially in the volcanic waters (Güler, 1997). The average concentration of the dissolved SiO_2 changes between 0.5 mg L^{-1} – 60 mg L^{-1} in the lakes around the world and it is about 13 mg L^{-1} in major rivers. The pollution impact of the SiO_2 in the water is less than the other pollutants (Horne and Goldman, 1994). The silicate which has a great importance on cell wall structure of siliceous algae and diatoms can be specified as one of the nutrients that was limiting the growth of the organisms in this study.

The lowest value of oil and grease was observed at the 2nd station which was prior to the discharge point meaning that the effluent of the treatment plant contributed to the amount of oil and grease pollution in Çerpeş Creek. However, when compared with untreated samples from a previously conducted study in a meat processing plant the values were observed to be low (Danış, 1996) indicating that the treatment system in the plant had a positive effect on reduction of the oil and grease load.

Some studies showed that untreated discharges of slaughterhouse wastewaters increase the BOD load of the system (Danış, 1996; Gürtekin and Ünlü, 2010). On the other hand, BOD values in the river bed were consistent with the BOD values of a study conducted in the Büyük Menderes Basin (Boyacıoğlu and Boyacıoğlu, 2004) indicating that discharge of the slaughterhouse has no effect alone in the increase of the pollution load in terms of BOD. Thus, the BOD values of the 2nd station which was prior to the discharge point were closer to the BOD values of the other stations that were located after the discharge point, supporting this evidence.

In summer and fall samplings the COD values in the 1st station exceeded the WPCR Food Industry Discharge Standards of the Receiving Environment. This may be because of the fact that the density of the slaughtering in the plant was high at the sampling date in which resulted in exceeding the limit values. On the other hand, COD values obtained in this study were comparable to the highest and lowest values of a study conducted recently at a treatment system of an integrated meat processing plant (Topal and Topal, 2011). In addition, COD values obtained in a meat processing plant's waste waters without a treatment system were measured to be very higher when compared to the COD values obtained in the Çerpeş Creek in this study (Danış, 1996; Gürtekin and Ünlü, 2010). However, high concentrations of BOD and COD detected from the 2nd, 3rd and 4th station during fall sampling can be due to the increase in organic matter via runoff after heavy rain fall in the area. Furthermore, the highest values of BOD and COD detected at the 1st station in the summer sampling were mostly because of the increased degradation rate of organic materials due to increased microbial activity at the time of this sampling (Katip and Karaer, 2011).

In a study conducted by Danış (1996) at an integrated meat plant, when the waste water was untreated the number of total coliform bacteria were very high (42x106 EMS/100 ml). The number of total coliform bacteria obtained in Çerpeş Creek, were observed to be lower than the study conducted by Danış (1996) indicating that the treatment system can reduce the bacterial load in the creek.

This study is important for the rivers in the region to be used specifically in paddy irrigation as well as other agricultural activities. Variables that are initially considered in paddy irrigation include temperature, salinity, and pH. Findings obtained from Cerpes Creek showed that the creek water can be used in paddy irrigation. However, it is not sufficient to make assessments only by considering the suitability of Cerpes Creek for paddy irrigation. It is also critical to periodically control other variables that may cause contamination for vital activities in the creek to continue a sustainable production and a balanced ecological system. Although the discharge water quality in the treatment plant where the study was conducted seemed to be suitable for irrigated agricultural use, it was also revealed that the treatment plant needed a revision as high values were observed in some variables such as nutrients, oil – grease, BOD, COD, fecal / total coliform bacteria. However, contamination load in the reference station (2nd station) was also high revealing that the contamination load in the creek cannot be eliminated only by revising the treatment system that was studied. In addition to revising the treatment system that was studied, other plants that discharge their waste into the creek must be equipped with relevant treatment systems as well.

Water quality is not only important for agricultural irrigation, but also important for the survival of the aquatic system itself. Therefore, in order to eliminate pollution of inland waters, the pollution load should be taken under control starting from the upstream.

The pollution in inland waters increases not only due to agricultural activities, but also due to industrialization, urbanization and population increase. While the industrialization and urbanization contribute to the development of the society, it also causes pollution at the same time. It is possible to battle pollution with the use of appropriate treatment techniques for the sector in line with evolving technology.

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References

Barlas, M. 1995. Akarsu kirlenmesinin biyolojik ve kimyasal yönden değerlendirilmesi ve kriterleri. Doğu Anadolu Bölgesi I. ve II. Su Ürünleri Sempozyumu, 465-479, Erzurum, (In Turkish).

Boyacıoğlu, H. and H. Boyacıoğlu. 2004. su kalitesinin istatistiksel yöntemlerle değerlendirilmesi. Su Kirlenmesi Kontrolü Dergisi, **14(3)**: 9-17, (In Turkish).

Danış, Ü. 1996. Et işleme tesisleri ve yerleşim yeri atıklarının karasu nehrine etkisi. Pamukkale Üniversitesi Mühendislik Fakültesi Mühendislik Bilimleri Dergisi, **2(1)**: 9-14, (In Turkish).

Eaton, A.D. and M.A.H. Franson (Eds.). 2005. Standard methods for the examination of water and wastewater.

Egemen, Ö. and U. Sunlu. 2003. Su kalitesi ders kitabı, (IV. Baskı). Ege Üniversitesi Basım Evi, Yayın No: 14, Bornova – İzmir. (In Turkish).

Ellis, K.V., White, G. and A.E. Adn Warn. 1989. Surface water pollution and it's control. Antony Rome Ltd., Chippenham, Wiltshire.

Güler, Ç. and Z. Çobanoğlu. 1997. Su kalitesi. I. Baskı. Çevre Sağlığı Temel Kaynak Dizisi No:**43**. Ankara, (In Turkish).

Gürtekin, E. and A. Ünlü. 2010. Elazığ organize sanayi bölgesi ve hayvan ürünleri organize sanayi bölgesi atıksularının değerlendirilmesi. Doğu Anadolu Bölgesi Araştırmaları. Fırat Üniversitesi Mühendislik Fakültesi Çevre Mühendisliği Bölümü. Elazığ. (In Turkish).

Horne, A.J. and C.R. Goldman. 1994. Limnology. Second Edition. 576 p., USA. McGraw-Hill.

Höll, K. 1979. Wasser (Untersuchung, Beurteilung, Aufbereitung, Chemie, Bakteriologie, Virologie, Biologie) 6. Auflage de Gruyter, Berlin, p: 586.

Mutlu, E., Yanık, T. and T.D. Karagöl. 2013. Hafik (Sivas)'in su kalitesinin incelenmesi. Alınteri Dergisi, **24(B)**:35-45. (In Turkish).

Odabaşı, S.S. 2005. Çanakkale Bölgesindeki Sarıçay akarsuyu'nda su kalitesinin araştırılması. Yüksek Lisans Tezi. Çanakkale Onsekiz Mart Üniversitesi, Türkiye, (In Turkish).

Polat, H. E. and M. Olgun. 2009. Hayvancılık işletmelerindeki atık yönetimi uygulamalarının su kirliliği üzerine etkileri. GOÜ. Ziraat Fakültesi Dergisi, **26(2)**:71-80. (In Turkish).

Schwörbel, J. 1987. Einführung in die limnologie, Gustav Fischer Verlag, Stutt-gart, 269 p.

Strickland, J.D.H. and T.R. Parsons. 1972. A practical handbook of seawater analysis. 2nd ed. Fisheries Research Board of Canada. **167**:310p.

Topal, M. and E.I. Topal. 2011. Bir entegre et tesisine ait arıtma tesisi çıkış sularının yaz sezonunda su kirliliği kontrolü yönetmeliği'ne uygunluğunun araştırılması. Balıkesir Üniversitesi Fen Bilimleri Enstitüsü Dergisi, **13(1)**:68-77, (In Turkish).

Ünlü, A., Çoban, F. and M.S. Tunç. 2008. Hazar Gölü su kalitesinin fiziksel kimyasal parametreler açısından incelenmesi. Gazi Üniversitesi Mühendislik Mimarlık Fakültesi Dergisi, **23(1)**:119-127, (In Turkish).

WPCR, 2012. Su Kirliliği Kontrol Yönetmeliği, (In Turkish).