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Determination of some physicochemical parameteres and inorganic nutrient content of Gediz River (Manisa)

Gediz Nehri (Manisa)'nın bazı fiziko-kimyasal özellikleri ve inorganik besin içeriğinin belirlenmesi

Abstract: Objective: This present investigation aimed at assessing the water quality of the Gediz River located in western Turkey.

Methods: Some physicochemical parameters and nutrient concentrations of the surface water of Gediz River were determined over a period of twelve months (October to September 2012) at 5 sampling sites along the river.

Results: Data on some ions namely NH_4-N, NO_2-N, NO_3-N and PO-34-P were measured. The pH, temperature, electrical conductivity (EC), salinity and dissolved oxygen were also determined to assess the chemical status and pollution levels of the river. The measured data were given as mean, maximum, minimum values, respectively. In this context; the ranges for Water temperature [17.95°C±1.37ºC (30.2-4.5)], pH [7.45±0.06 (8.11-6.66)], Dissolved Oxygen [3.84±0.65 mg/L (6.25-2.43)], Electrical Conductivity (E.C) [1051.4±216.07 µS/cm (3000-296)], Salinity [0,16±0,05 ppt (0,8-0,1)], Ammonium nitrogen (NH_4-N) [1.772±0.8228 mg/L (4.642-0.057)], Nitrite nitrogen (NO_2-N) [0.605±0.4224 mg/L (2.312-0.050)], Nitrate nitrogen (NO3-N) [46.014±44.9878 mg/L (151.965-2.855)], Phosphate phosphorus (PO-34-P) [5.489±3.6356 mg/L (20.350-0.190)] were found to be higher than the natural background levels for surface water.

Conclusion: This indicates pollution of the river water samples from the areas studied. Our findings highlighted the deterioration of water quality of the river due to anthropogenic and agriculturel activities.

Keywords: Physicochemical parametres, Gediz River, nutrient and water quality

Özet: Amaç: Mevcut araştırmada batı Türkiye'de bulunan Gediz Nehri'nin su kalitesini değerlendirmek amaçlanmıştır.

Metod: Gediz Nehri'nin yüzey suyunun bazı fizikokimyasal parametreleri ve nutrient konsantrasyonu nehir boyunca 5 örnekleme bölgesinde on iki aylık (Eylül 2012 Ekim 2011) bir süre boyunca belirlenmiştir.

Bulgular: Yüzey suyunda bulunan NH_4-N, NO_2-N, NO_3-N ve PO-34-P gibi bazı iyonların konsantrasyonları ölçüldü. pH, sıcaklık, elektriksel iletkenlik (EC), tuzluluk ve çözünmüş oksijen de nehrin kirlilik düzeylerini ve kimyasal durumunu tespit etmek için değerlendirilmiştir. Ölçülen veriler sırasıyla ortalama, maksimum, minimum değerler olarak verilmiştir. Bu kapsamda; sıcaklık için 17,95±1,37ºC (30,2-4,5); pH için 7,45±0,06 (8,11-6,66); çözünmüş oksijen için 3,84±0,65 mg/L (6,25-2,43); E.C için (25ºC) 1051,4±216,07 µS/cm (3000-296); tuzluluk için 0,16±0,05 ppt (0,8-0,1); amonyum azotu için (NH_4-N) 1,772±0,8228 mg/L (4,642-0,057); nitrit azotu için (NO_2-N) 0,605±0,4224 mg/L (2,312-0,050); nitrat azotu için (NO-3-N) 46,014±44,9878 mg/L (151,965-2,855); orta fosfat fosforu için (PO-34-P) 5,489±3,6356 mg/L (20,350-0,190) olarak belirlenen ortalama değerler yüzey suyu için olması gereken seviyesinden daha yüksek olduğu bulunmuştur.

Sonuç: Bu, çalışılan alanlardaki nehir su örneklerinin kirliliğini gösterir. Bulgularımız insan kaynaklı ve tarımsal

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faaliyetler sebebiyle nehrin su kalitesinin bozulmuş olabileceğini vurgulamaktadır.

Anahtar Kelimeler: Fiziko-kimyasal özellikler, Gediz Nehri, nutrient, su kalitesi

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Introduction

Over 70% percent of Earth's surface is covered with water. Oceans contain 97% percent of the earth's water where is the majority of the rest of the water. 3% percent of the world's water is freshwater and earths freshwater mostly is found in frozen in glaciers and underground were found at depths that are difficult to economically remove. Besides 0.003% percent of this water is achievable. Therefore, the available freshwater is very limited in lakes, streams and groundwater. This situation draws on underlines the importance of existence and persistence of terrestrial life again [1].

A source of freshwater is less than the sum of potential because the precipitation is not uniformly distributed around the globe. The distribution of the human population is not commensurate with the availability of freshwater, and most importantly, water resources are polluted at an increasing rate [2]. There is no increase in the global fresh water resources, and the need for clean water is increasing day by day due to contamination of sources.

In most developing countries, discharges from point sources have increased significantly as a result of industrialization and high living standards. Additionally, excessive inorganic nutrient loads to rivers in these countries has been accompanied by untreated wastewater discharges [3]. The Global Environmental Monitoring System (GEMS) of the United Nations Environmental Program (UNEP) reported heavy pollution in several rivers around the World (Bichi and Anyata, 1999). Water pollution size affects live life of aquatic ecosystem. When an ecosystem gets polluted, the natural balance in the system is disturbed the emergence of a certain level of pollutants in the environment and this affects human health via organisms that make up the food chain (Anonymous 2005-a). In line with "Water Framework Directive" (WFD) adopted by the European Community, scientists carry out studies in order to ensure good ecological status of aquatic ecosystems in Europe and associated ecosystems [4].

In Turkey, the Water Pollution Control Regulation (WPCR) have comprehensive regulations intended to control water pollution [5]. In this regulations, protection of the ecosystem quality within the framework of the ecosystem principle and improvement of water quality in line with national requirements are targeted. Besides surface water quality classification is made. Most of freshwater basins are not under the protection in Turkey, and they are in the form of receiving environments of domestic, industrial and agricultural pollution sources. In line with objectives of WFD and WPCR, characteristics and quality of freshwater resources must be determined, and the necessary measures must be taken. In recent years, the number of studies to determine of water quality of lentic and lotic systems has increased considerably in Turkey [6-14].

In this study, inorganic nutrient content were determined by examining some of the physico-chemical properties of Gediz River containing a combination of a number of different industry group discharges. Analysis results were evaluated according to WPCR (Table 1), and other drinking water quality criteria [15-18], (Table 2). The results using statistical methods (SPSS 16 program) were evaluated.

Table 1: Some quality criteria according to intra-continental water spring classification [5].

Water quality parameters	Water quality classification			
	I	II	III	IV
Temperature (°C)	20	25	30	>30
pH	6.5-8.5	6.5-8.5	6.0-9.0	6.0-9.0
Dissolved oxygen (mg/L)	8	6	3	<3
NH_4-N (mg/L)	0.2	1.0	2.0	>2.0
NO_2-N (mg/L)	0.002	0.01	0.05	>0.05
NO_3-N (mg/L)	5	10	20	>20
PO_4^{-3} (mg/L)	0.02	0.16	0.65	>0.65

Table 2: The most highly recommended values of some parameters of drinking water standards.

Parameters	EC (1998)	TS 266 (2005)	WHO (2008)	EPA (2009)
pH	6.5-9.5	6.5-9.5	6.5-8.0	6.5-8.5
Temperature (°C)	–	25	–	–
Ammonium (mg/L)	1.5	0.50	1.5	–
Nitrate (mg/L)	50	50	50	10
Potassium (mg/L)	–	12	–	–

Material and Methods

The city of Manisa is located in the western Aegean region and an important agricultural and industrial center of

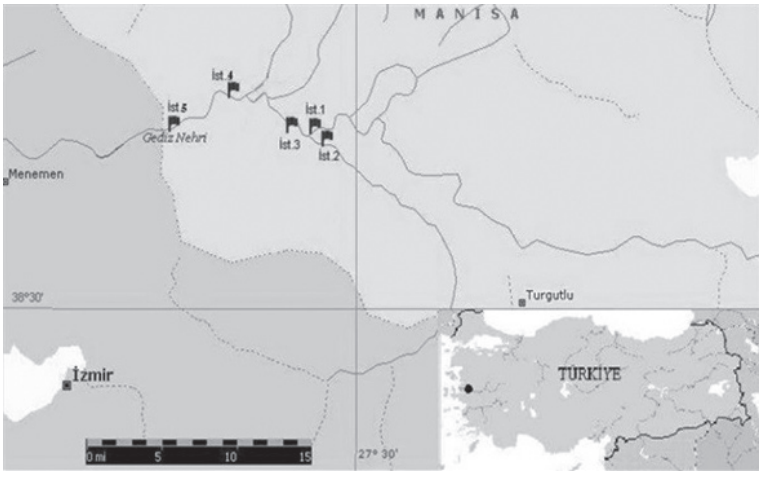

Figure 1: Location of the study area and sampling points.

Turkey. Gediz River Basin lies between northern latitudes of 38°04'-39°13' and southern longitudes of 26°42'-29°45' [19]. Gediz River rises from Murat Mountain and Şaphane Mountain in Kütahya Province and flows through Uşak, Manisa and İzmir Provinces. It joins the sea in the northern section of the Gulf of Izmir, close to the gulf's mouth, near the village of Maltepe in Menemen district, south of the coastal town of Foça [20]. There are a large number of industrial companies in the basin areas such as metal, mining, chemistry, soil products, food, paper, and leather processing industry. Specific stations were selected in the study area taking into account the pollution load of these organizations. In the present study, water samples were taken from five stations (Figure 1) with positions recorded as GPS coordinates (Table 3).

Samples were collected during the period of October 2011 to September 2012. Surface water pH, temperature (DKK-TOA product WQC 20A model), dissolved oxygen, electrical conductivity and salinity (YSI 30 SCT) were measured at each sampling point at collection. Samples of water were transported to the laboratory at 4°C and analyzed within 1-6 h [21,22]. The concentration of phosphate, nitrate, nitrite and ammonium ions were determined by spectrophotometric methods [21] at 700 nm, 543 nm, 543 nm and 640 nm, respectively, using a Varian Cary 50 spectrophotometer. SPSS 16 package program was used for statistical analyses. Analysis of variance (one-way ANOVA and Tukey test) was used to determine significance differences existed among stations and months of inorganic nutrient concentrations.

Results and Discussion

In this study, some physico-chemical features in the surface water in Gediz River have been investigated between October 2011 and September 2012. In addition, the lake has been evaluated according to water quality criteria. The physical and chemical parameters of water and the level of inorganic nutrient concentration in surface water samples are analyzed in five different stations of Gediz River. Physicochemical properties and inorganic nutrient concentration of the stations are shown on Table 4 and Figure 2-5 (mean, standard deviation, minimum and maximum values, respectively).

Minimum and maximum values for pH were measured to be 6.66 (January 2012) and 8,11 (October 2011), respectively. The Gediz River largely exhibited slightly alkaline pH of natural waters in the range of 6.66 to 8.11 with

Table 3: Sampling points and coordinates on Gediz River.

S/N	Station	Coordinate
1	Istanbul road Gediz bridge	38°38'37.06" N, 27°26'32.49" E
2	Nif straem	38°38'34" N, 27°26'33.59" E
3	Manisa Municipality wastewater treatment plant	38°38'34.62" N, 27°26'31.62" E
4	Muradiye Gediz bridge	38°39'4056" N, 27°18'44.27" E
5	Gediz Izmir frontier	38°37'22.77" N, 27°06'55.03" E

Table 4: Mean (M), standard deviation (S.D), minimum (min.) and maximum (max.) values of physicochemical parameters and inorganic nutrient concentration of stations. Mean values with the same letter within the same row are not significantly different (p>0.05).

Parameters	Stations (St)				
	St 1	St 2	St 3	St 4	St 5
pH	7.46±0.55	7.42±0.38	7.36±0.38	7.49±0.39	7.54±0.36
	7.76–8.11	6.80–7.93	6.71–7.94	6.66–8.01	6.81–8.03
Temperature (°C)	17.13±8.41	17.39±9.17	20.09±7.35	17.2±7.4	17.64±8.13
	7.4–28.50	4.5–30.2	7.5–29.8	7.5–25.7	7.6–28.8
D.O (mg/L)	4.89±0.99	3.7±0.86	3.09±0.22	3.79±0.37	3.75±0.47
	3.40–6.25	2.43–4.79	2.47–3.35	3.36–4.41	3.11–4.32
E.C (25°C) µS/cm	1080.583±963.58	1317.166±726.11	794±285.67	949.25±473.97	962.583±442.65
	296–3000	285–2010	420–1047	394–1568	466–1602
Salinity (ppt)	7.54±0.36	4.450±0.355	0.175±0.136	0.267±0.246	0.267±0.246
	6.81–8.03	0.1–0.8	0.2–0.3	0.2–0.6	0.2–0.6
Ammonia (mg/L)	0.939^{b}±1.008	2.201^{a}±0.521	2.521^{a}±1.159	1.708^{ab}±0.691	1.491^{ab}±0.735
	0.057–3.051	1.012–2.764	0.516–4.642	0.879–2.860	0.585–2.690
Nitrite (mg/L)	0.776^{a}±0.669	0.629^{a}±0.574	0.353^{a}±0.275	0.629^{a}±0.281	0.638^{a}±0.313
	0.069–2.118	0.192–2.312	0.050–0.793	0.190–1.203	0.132–1.028
Nitrate (mg/L)	60.812a±34.294	39.118^{a}±52.451	33.899^{a}±51.228	47.721^{a}±42.731	48.520^{a}±44.235
	7.844–126.744	2.906–151.965	3.235–151.614	2.855–132.180	4.215–125.993
Ortho phosphate	3.074^{b}±3.263	4.842^{ab}±4.527	12.678^{a}±5.599	3.560^{b}±2.630	3.293^{b}±2.159
	0.475–12.160	0.190–16.509	1.235–20.350	0.855–9.215	0.570–8.075

an average value of 7.45 which is consistent with the data in the literature [12,14]. The lowest and highest pH values were observed at Muradiye Gediz Bridge (st.4) and Istanbul Road Gediz Bridge (st.1) respectively (Table 3). The pH values were within the "no effect" range of 6.0-9.0 for drinking water use [23] and the WHO range for drinking and potable water of 6.5 to 8.0 [17]. It was slightly above the natural background level of 7.0. This increase in pH of the water samples above the normal background levels may be due to the presence of dissolved carbonates and bicarbonates present in the water, which are known to affect pH of almost all surface water [24] (Table 4).

The lowest temperature (4.5°C) and highest temperature (30.2°C) in the river were observed in January 2011 and August 2012, respectively. The highest temperature was determined in station 3 because of the spread of a shallow area of the riverbed. The temperature values has been in compliance with studies conducted in the region [14,25] (Table 4).

DO is one of the limiting and regulating factors for aquatic organisms. The amount of oxygen can change with respect to the water temperature, dissolved salt concentration, partial pressure of the gas in the atmosphere and mobility of water. The concentration of DO can increase in situations like carbon dioxide extraction (photosynthesis), current velocity, wind increase, temperature decrease or increase, organic matter decomposition and oxidation reactions [26–28]. The DO values in Gediz ranged from a minimum of 2.43 mg/L to a maximum of 6.25 mg/L with a mean value of 3.84 mg/L. DO values showed seasonal variations during the study, and the values are determined to be lower than the other studies [14]. DO values were low at station 3 in particular because the average temperature of station 3 was lower than the other stations. When analysis results compared with Water Pollution Control Regulation (WPCR) and Drinking and Usage Water Standards [15-18], the lake water was determined to be at third quality [5] in terms of DO (Table 4).

EC is the numerical expression of an aqueous solution to carry electrical current and is a useful indicator of the mineralization in a water sample [25]. The conductivity values ranged from a minimum of 296 µS/cm to a maximum of 3000 µS/cm with a mean value of 1051.4 µS/cm which is consistent with the data in the literature [29]. The WHO limit for EC for drinking and potable water is 700 µScm [17]. This limit was exceeded in all of the stations Based on this parameter, these five stations are not suitable for domestic use. Health effects in humans for consuming water with high EC may include disturbances of salt and water balance; and adverse effect on certain myocardic patients and individuals with high blood pressure [30] (Table 4).

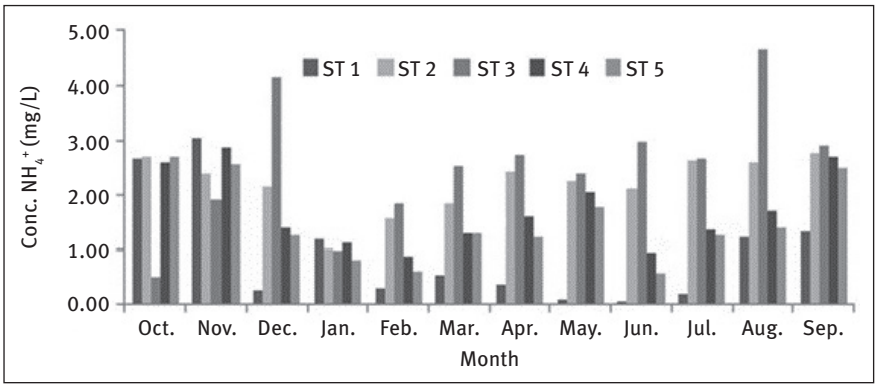

Figure 2: Ammonium ion (mg/L) change of stations by month.

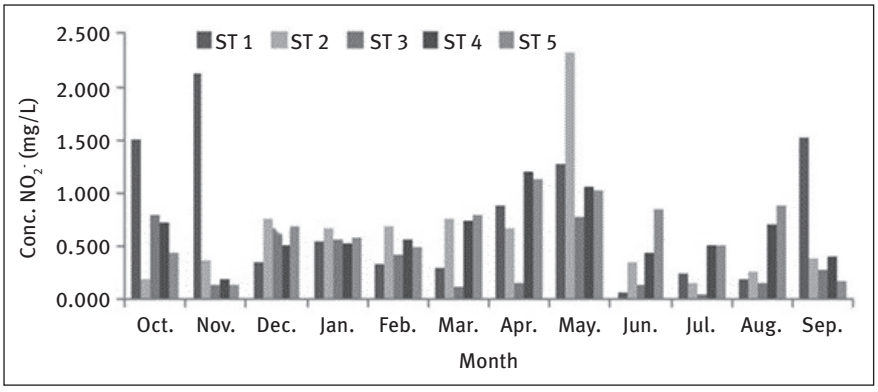

Figure 3: Nitrite ion (mg/L) change of stations by month.

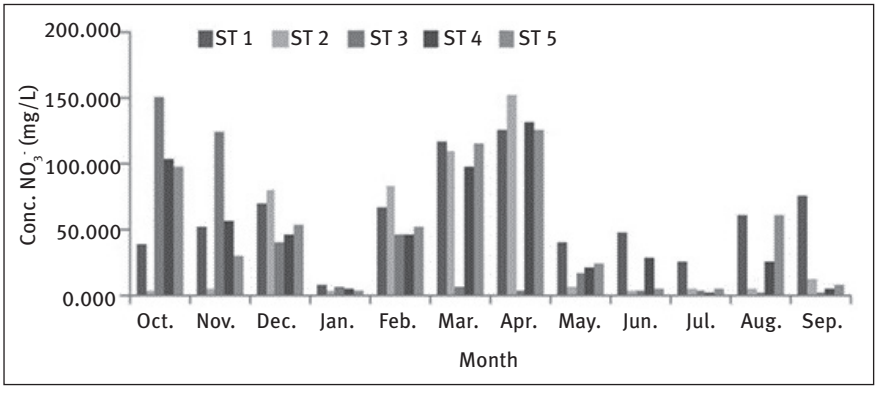

Figure 4: Nitrate ion (mg/L) change of stations by month.

The salinity values ranged from a minimum of 0.1 ppt (in March at station 2) to a maximum of 0.8 ppt (in November at station 2) with a mean value of 0.16 ppt. The salinity was almost constant on surface waters with 0.7-0.8 ppt, its due to lack of precipitation during November 2011 (Table 4).

The lowest concentration of ammonium in the water samples is 0.057 mg/L NH_4^+ (in June at station 1), the highest concentration of ammonium was measured as 4.642 mg/L NH_4^+ (in August at station 3). Monthly average ammonium concentration of all stations is 1.772 mg/L. Amounts of ammonium showed significant difference among the stations ($p<0.05$) but the difference was insignificant among the months ($p>0.05$). According to the statistical test of mean ammonia concentrations, station 1 showed a significant difference compared to all stations except st. 4 and st. 5 ($p<0.05$) (Table 4). Ammonium in the water occurs by degradation of the organic material in the water. Thus, domestic and industrial organic wastes, intensive aquacul-

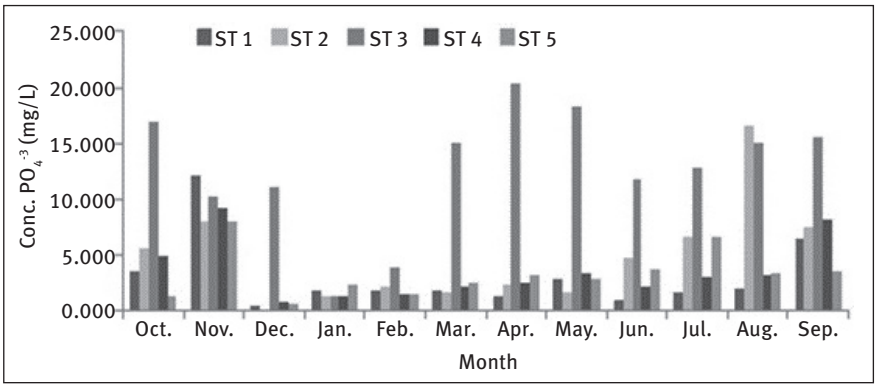

Figure 5: Ortho-phosphate phosphorus (mg/L) change of stations by month.

ture and ammonification of urea sourced from organisms in water increases the amount of ammonium concentration [22]. Unpolluted rivers don't have more than 0.04 mg/L ammonium while it is found 1 mg or less per liter in clean water [2]. According to these two criteria, in terms of ammonium, water of the Gediz River is in the polluted water class. Determined ammonium concentration was higher than all drinking water limits. In terms of quality criteria, the region water was found to be III. quality [5]. The ammonium concentration of stations 3 was found higher than that of station 1. This finding reveals that the amount of dissolved oxygen in the water is low. Therefore, nitrite and nitrate may turn into ammonium. The pollution is thought to result from agriculture and husbandry activities and industrial wastewaters depending on precipitations [31].

Minimum and maximum values for nitrite ion were determined to be 0.050 (July 2012) and 2.312 (May 2012) mg/L, respectively (Figure 3). Nevertheless, minimum and maximum values for nitrate ion were measured to be 2.855 (July 2012) and 151.965 mg/L (April 2012), respectively (Figure 4). According to the statistical test of mean nitrite concentrations, there was no statistically significant difference among the stations and months ($p>0.05$) (Table 4). According to the statistical test of mean nitrate concentrations, there was statistically significant difference among the months ($p<0.05$) (Table 4). Nowadays, the use of nitrogen fertilizer is equivalent to 26 times more of phosphorus fertilizer. Nitrogen fertilizer, which is a lively form of nitrate ions, is released from agricultural areas to infiltrate. As a result, the nitrogen and phosphorus content increases in fresh water [32]. The concentrations of nitrate determined at the various sampling points ranged from 0.123 mg/L (in September at station 3) to 151.965 mg/L (in April at station 2) with a mean value of 46.014 mg/L. This concentration is well above of 0.2 mg/L value which is the highest amount that can be found in clean rivers [2]. The measured values of both nitrite and nitrate indicate domestic and agricultural discharge into the stream. Amount of nitrate had statistically insignificant difference among the stations ($p>0.05$), but significant difference between the months ($p<0.05$). Nitrate concentration determined on the Gediz River was lower than drinking water standards determined by USA, WHO, EU and TS-226 [15-18] and the river, in terms of Nitrate concentration, was found to be IV. quality [5]. Presence of nitrite is not allowable in drinking water. Because entire absence of these ions is the most healthy state. Nitrite can reach high concentrations where there are organic pollution and low oxygen [22]. The concentrations of nitrite determined at the various sampling points ranged from 0.050 mg/L (in July at station 3) to 2.312 mg/L (in May at station 2) with a mean value of 0.605 mg/L. Amount of nitrite was found statistically insignificant ($p>0.05$). In particular, nitrate and nitrite concentration of river water may be increased due to fertilizer discharge into the river with rainfall in the months March, April and May. Measured nitrite concentration is found at high level according to the drinking water standards determined by TS-226 [16]. In terms of nitrite, examined water was determined to be IV. quality [5].

Phosphate concentration in the water ranged from 0.19 mg/L (in December at station 2) to 20.350 mg/L (in April at station 3) (Figure 5) with a mean value of 5.489 mg/L which is the highest data when compared to the other literatures [6,14]. According to the statistical test of mean ortho phosphate phosphorus concentrations, station 3 showed a significant difference compared to all stations ($p<0.05$) and there was no statistically significant difference among the months ($p>0.05$). (Table 4). The highest phosphate concentration of 20.350 mg/L was measured at st.3. The observed dominance of phosphate could be due to the large amount of domestic wastes being discharged into the river and its tributaries. According to the limit values of WHO (2008), EC (1998), EPA (2009) and TS-266 (2005) [15-18], phosphate concentration of surface

water was found to be at low level. According to the WPCR, river water has been observed as IV. quality criteria [5].

Phosphate and ammonium values were determined to be high especially at the station 3. Collection of domestic wastewater of Manisa city in this area and accumulation of detergent materials used in waste water seemed to be the main reason of this result. Nitrite and nitrate concentrations were determined high especially at the station 1 due to discharge of fertilizers with precipitations into the river. These stations of Gediz riverwere determined to be IV. class quality criterion in the measurement range. Our findings highlighted the deterioration of water quality of the river due to anthropogenic and agricultural activities.

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Conflict of Interest: The authors have no conflict of interest.

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