http://communications.science.ankara.edu.tr

Commun.Fac.Sci.Univ.Ank.Ser. C Biology
Volume 31, Number 2, Pages 187-206 (2022)
ISSN 1303-6025 E-ISSN 2651-3749
DOI: 10.53447/communc.1171792

Research Article; Received: September 6, 2022; Accepted: October 25, 2022

ÇUBUK STREAM POLLUTION AND ENVIRONMENTAL EFFECTS

TAHİR ATICI[1*], DİDEM BALOĞLU ONGAR[2]

[1] Department of Biology Education, Gazi Education Faculty, Gazi University, TURKEY
[2] Ministry of National Education, Biology Teacher, TURKEY

ABSTRACT. The water quality parameters of Çubuk Stream were examined in terms of physical and chemical aspects and the pollution level of Çubuk Stream was determined by comparing these parameters with the Surface Water Quality Regulation (SWQR). For this purpose; samples were taken from three different stations between August 2012 and April 2013, the water samples were compared with each other and with previous studies, the water quality of Çubuk Stream was determined according to the surface water quality regulation. In our study, the biological oxygen requirement of Çubuk Stream according to SWQR (BOD5: 22.5mg/l) IV. class, ammonium nitrogen element (NH4–N:2.34 mg/l) IV. class, nitrite nitrogen element (NO2–N: 0.035 mg/l) II. class, nitrate nitrogen element (NO3 –N:0.95 mg/l) Class I, according to phosphate value (PO4:0.075 mg/l) Class I and trace elements (Pb, Cd, Cr, Ni, Mn) values Class I. water quality. According to the ratio of NH4-N/PO4 (2.34/0.075=31.2 mg/l), the element that limits eutrophication in Çubuk Stream is P. Compared to previous studies, after the wastewater treatment plants established in the region, higher quality water is provided, especially in terms of NO3 and PO4. It has been determined that the nitrogen and phosphorus ratios are high because the region, which is dense in terms of organic matter, is close to industrial establishments.

1. INTRODUCTION

Water is one of the indispensable elements of our life. Besides being an important inorganic nutrient, water; as a good solvent and carrier, minerals and compounds play an active role in the realization of all kinds of biochemical reactions in our body [1]. Therefore, a life without water is not possible. Water concerns the living thing and everything it affects. Although the fact that 75% of our earth is covered with water shows that the world has

Keywords. Water quality, Çubuk Creek, water pollution, physical and chemical parameters
tahir@gazi.edu.tr - Corresponding author; 0000-0002-3396-3407
db.generous@gmail.com; 0000-0003-2917-0102

a large water reserve, the rate of drinkable water is only below 1%. As of 1765, while the industrial revolution was in its infancy, the world population reached 1 billion, 2.5 billion in the last quarter of the 20th century, and 8.5 billion towards 2020.

The increase in the population in our world, the rapid development of industry and technology, as well as the inability to establish or spread environmental awareness sufficiently, cause the amount of potable water in the world to decrease gradually. In addition, it is inevitable that irreparable ecological problems occur due to unconscious pollution of potable water density [2]. It is predicted that a universal water crisis will emerge with the increase in the required water density and the intersection of clean water reserves in 2030 according to the estimates [3]. In recent years, studies have been carried out especially for the monitoring of freshwater resources. This is an indication that the importance of water in today's world has become very important on a global scale [4].

Excessive algae growth in water occurs when nutrient elements such as nitrogen and phosphate coming from wastewater mixed with rivers, especially from agricultural soils by drainage and rain water, reach the maximum level (0.8 mg/l N [nitrogen] and 0.1 mg/l P [phosphorus]). This is called secondary pollution or eutrophication [5]. Nitrogen in water is mostly in the form of ammonium, nitrite and nitrate. In waters with high oxygen content, ammonium is found at very low levels. Ammonium nitrogen is the waste material of living things in aquatic ecosystems and can be reabsorbed by these organisms [6]. Nitrite is an intermediate in the biological oxidation from ammonium to nitrate. It is known that nitrite rate is low in clean surface waters and high in polluted surface waters [7]. Nitrate, the most common form of nitrogen in surface waters, occurs in oxygen-rich waters. Nitrate is an important element that can limit or increase the growth of algae. Nitrogen content is low in oligotrophic waters and quite high in eutrophic waters [8]. Phosphorus, which affects the productivity of natural waters and is one of the most basic elements of eutrophication, has a limiting effect on the growth of autotrophic and heterotrophic organisms. It also gives information about the presence of phosphorus, organic matter mixed with water and the presence of household waste. Depending on the presence of detergent in household wastes and the organic metabolism in the water, changes are seen in the phosphorus ratio. Phosphorus is found in trace amounts in uncontaminated waters [9-11].

The aim of this study; to determine the extent of the pollution of Çubuk Stream, which is an important water source for Ankara, to compare the

situation before and after the establishment of treatment plants in the region according to physical and chemical parameters, to determine which element is limited by the system by looking at the nitrogen and phosphorus amounts of the eutrophication event observed in Çubuk Stream. In addition, the results of the research are important for the control of Çubuk Stream water pollution, by determining the factors causing pollution, ensuring that these factors are brought to normal standards by taking into account the interests of the country's economy, in the development of other studies and in terms of its contribution to the scientific literature.

1.1. Geographical structure of the region

Çubuk Stream is an important water source for Ankara. Located in the north of the city center of Ankara, this stream crosses the Ankara plain between 40°00' - 40°18' latitudes and 32°53' - 33°08' longitudes. The Çubuk Stream, which originates in two branches from the Aydos Mountains within the Köroğlu Mountain mass and continues to the south, is 84 km long and is located in the Sakarya River Basin. The total precipitation area of the basin is 58160 km² [12] (SHW [State Hydraulic Works], 2006). The Çubuk Stream, which passes through Çubuk district center, divides the district into two. Although there are many side streams that mix with the stream, the Çubuk Stream has an average flow of 0.5 m³/sec, since they do not have much water. The heaviest time of the Çubuk Stream is in late spring and the heaviest time is late summer and early autumn. Summers in the region are hot and dry, and winters are cold and rainy. The lowest recorded temperature is -21.5 ^{0}C, and the hottest temperature is 37.7 ^{0}C. Rain averages are 472 mm³ [13].

2. MATERIALS AND METHODS

2.1. Determination of Physical and Chemical Parameters of Water

Water samples were taken from 3 different stations on Çubuk Stream in August 2012, November 2012, January 2013 and April 2013. While determining the parameters in this study, the water quality parameters based on the SWQR [14,15] quality criteria were considered. Biological oxygen demand from oxygenation parameters; nutrient parameters such as ammonium, nitrite and nitrate nitrogen, and the amount of phosphate; among the trace elements, parameter values such as cadmium, lead, copper, nickel

and zinc were examined. With these values, quality criteria were made according to the classes of inland surface water resources.

After the Karaköy and Çubuk Wastewater Treatment plants were opened in 2009, no study was conducted on Çubuk Stream. Therefore, because of this study, the parametric values of the base stations were compared with the studies before 2009. N and P amounts were determined in the studied stations of Çubuk Stream and it was revealed which of the N and P elements that caused the eutrophication event had a limiting effect. Physical and chemical parameters such as pH, EC, BOD5, B, PO4 -P, SO4, S, CN, Zn, NH4-N, Al, Fe, NO2-N, NO3-N, Cl, F, ˚F, Cu, Pb, Cd, Cr, Ni, Mn were analyzed. Physical parameters were analyzed with Multi Parameter Water Quality Meter WQC-24, chemical parameters were analyzed with The Spectroquant NOVA 60 photometers.

2.2. Selection and Definition of Water Sample Stations

In order to analyze the physical and chemical parameters, water samples were collected from 0.5-liter unused sterile water bottles, approximately 5 cm from the surface of the water; it was taken from the widening parts of the Çubuk Stream bed where the current is low, and the water seems clear.

Station 1 is the exit of Çubuk 2 Dam. Çubuk 2 Dam was established on Çubuk Stream, 54 km north of Ankara, 5 km north of Çubuk, in a place where the valley is relatively narrow to meet the water needs of the city. There are many factories in the area after the 1st station. There are feed-food industry, flour industry, tile industry, concrete pipe and parquet, glass industry, pharmaceutical industry and agriculture areas as well as slaughterhouses.

In the region where factories are concentrated between the 1st station and the 2nd station, there is Çubuk Wastewater Treatment Plant. This facility was put into service in 2009 in order to treat the wastewater of Çubuk district and its neighborhoods.

2nd station: It was taken from an Ülker factory near the Akyurt district of Ankara, in the Pursaklar-Saray region on the Esenboğa airport road. There are many slaughterhouses in this region. There is Karaköy Wastewater Treatment Plant between the 2nd station and the 3rd station. Located in Karaköy, this facility; It treats the wastewater of a part of the Pursaklar district, Akyurt district and Esenboğa, Sirkeli, Karacaören, Altınova and

Sarayköy districts, as well as the surrounding neighborhoods and settlements. It was put into service in 2009 [13].

3rd station: it was taken from Torunoğlu concrete pipe industry zone from the lower side of Keçiören-Hasköy Bridge. Next to this area is Erdemler furniture factory. It is a residential area. The bottom of the stream is covered with mud.

3. RESULTS

Measurements of physical and chemical parameters of Çubuk Stream are given in Table 1-5.

TABLE 1. Some physical and chemical properties of Çubuk Stream according to stations in August 2012

Control Parameters	**First Station Çubuk (Dam Exit)**	**Second Station Saray-Esenboğa Road**	**Third Station Kecioren-Haskoy**
EC µS/cm	319	1247	1256
pH	7.75	7.17	7.11
BOD5	15	24	47
B (µg /L)	0.12	8.5	0.31
P04 (mg/l)	0.07	0.09	0.09
$SO4^{=}$ (mg/l)	130.2	141.1	132.22
S (mg/l)	0.035	0.285	10.05
CN^{-} (µg /L)	0.006	0.006	0.008
Zn (mg/l)	0.24	0.41	0.47
NH4 -N (mg/l)	0.07	0.27	1.14
Al (mg/l)	0.01	0.01	0.01
Fe (mg/l)	0.12	0.42	0.60
NO2 -N (mg/l)	0.03	0.01	0.01
NO3 –N (mg/l)	1.6	1	1.4
Cl^{-} (mg/l)	11	204	136
F^{-} (mg/l)	<0.1	0.11	0.07
°F (Fr)	0.01	0.01	0.01
Cu (µg/L)	0.870	0.144	0.310
Pb (µg/L)	0.250	0.250	0.873
Cd (µg/L)	0.02	0.02	0.03
Cr (µg /L)	0.12	0.38	0.44
Ni (µg/L)	0.46	0.34	0.74
Mn (mg/l)	0.74	0.34	0.46

TABLE 2. Some physical and chemical properties of Çubuk Stream according to stations in November 2012

Control Parameters	First Station Çubuk (Dam Exit)	Second Station Saray-Esenboğa Road	Third Station Keçioren-Haskoy
EC µS/cm	317	918	1166
pH	8.04	7.72	7.51
BOD5	9	29	45
B (µg/L)	0.1	0.15	0.17
P04 (mg/l)	0.075	0.08	0.09
$SO4^{=}$ (mg/l)	16.02	38.2	91.2
S(mg/l)	0.035	0.027	0.037
CN^{-} (µg/L)	0.005	0.003	0.004
Zn (mg/l)	0.39	2.55	0.87
NH4 -N (mg/l)	0.44	3.81	3.54
Al (mg/l)	0.01	0.01	0.01
Fe (mg/l)	0.33	0.10	0.14
NO2 -N (mg/l)	0.04	0.59	0.02
NO3 -N(mg/l)	0.1	3.4	0.10
Cl^{-} (mg/l)	21	98	102
F^{-} (mg/l)	0.26	0.29	0.10
°F (Fr)	20	32	30
Cu (µg/L)	0.01	0.01	0.01
Pb (µg/L)	0.040	0.026	0.144
Cd (µg/L)	<0.1	<0.1	<0.1
Cr (µg/L)	0.02	0.02	0.03
Ni (µg/L)	0.12	0.12	0.12
Mn (mg/l)	0.02	0.05	0.02

TABLE 3. Some physical and chemical properties of Çubuk Stream according to stations in January 2013

Control Parameters	First Station Çubuk (Dam Exit)	Second Station Saray-Esenboğa Road	Third Station Kecioren-Haskoy
EC µS/cm	258	916	1092
pH	7.8	7.7	7.2
BOD5	8	18	40
B (µg/L)	0.09	0.13	0.17
P04 (mg/l)	0.07	0.07	0.07
$SO4^{=}$ (mg/l)	14.02	36.3	82.4
S (mg/l)	0.035	0.027	0.035
CN^{-} (µg/L)	0.02	0.02	0.03
Zn (mg/l)	0.36	2.50	0.91
NH4 -N(mg/l)	0.56	3.9	3.63
Al (mg/l)	0.02	0.02	0.01
Fe (mg/l)	0.10	0.10	0.10
NO2-N (mg/l)	0.05	0.55	0.02
NO3 -N (mg/l)	0.1	3.1	0.9
Cl^{-} (mg/l)	10	62	94
F^{-} (mg/l)	0.25	0.25	0.10
°F (Fr)	20	32	30
Cu (µg/L)	0.01	0.01	0.01
Pb (µg/L)	0.040	0.026	0.144
Cd (µg/L)	<0.1	<0.1	<0.1
Cr (µg/L)	0.02	0.02	0.02
Ni (µg/L)	0.12	0.12	0.12
Mn (mg/l)	0.02	0.05	0.02

TABLE 4. Some physical and chemical properties of Çubuk Stream according to stations in April 2013

Control Parameters	First Station Çubuk (Dam Exit)	Second Station Saray-Esenboğa Road	Third Station Keçioren-Haskoy
EC µS/cm	280	964	1102
pH	7.9	7.7	7.3
BOD5	8	21	40
B (µg/L)	0.1	0.14	0.21
P04 (mg/l)	0.06	0.07	0.07
$SO4^{=}$ (mg/l)	73.6	81.7	110.3
S (mg/l)	0.030	0.14	3.02
CN^{-} (µg/L	0.006	0.006	0.008
Zn (mg/l)	0.30	2.45	0.62
NH4 -N (mg/l)	0.60	3.90	3.70
Al (mg/l)	0.02	0.01	0.01
Fe (mg/l)	0.22	0.10	0.12
NO2 -N (mg/l)	0.06	0.33	0.02
NO3 -N (mg/l)	0.4	2.5	0.8
Cl^{-} (mg/l)	15	83	85
F^{-} (mg/l)	<0.1	0.21	0.10
°F (Fr)	0.01	0.01	0.01
Cu (µg/L)	0.04	0.01	0.01
Pb (µg/L)	0.097	0.074	0.320
Cd (µg/L)	<0.1	<0.1	<0.1
Cr (µg/L)	0.01	0.01	0.02
Ni (µg/L)	0.10	0.11	0.11
Mn (mg/l)	0.02	0.07	0.02

TABLE 5. Çubuk Stream; comparison with water quality parameters SWQR 2015

Parameters	Water Quality Classes			Çubuk Stream (Average value)
	I	II	III	
pH	6.5-8.5	6.5-8.5	6.5-8.5	7.7
PO4 (mg/l)	0.03	0.20	0.50	0.075
NO2 (mg/l)	<0.01	0.06	0.12	0.035
NO3 (mg/l)	5	7.5	15	0.95
NH4 (mg/l)	<0.2	1	2	2.34

The comparison of the pollution parameters of Çubuk Stream taken from approximately the same location [16] from the water analyzes before and after the opening of the wastewater treatment plants is shown in Table 6.

TABLE 6. Average annual values of some physical and chemical parameters before and after the establishment of the wastewater plant.

Control Parameters	Second Station Saray-Esenboğa road	Third Station Keçiören-Hasköy	Çubuk and Karaköy Before Waste Water Treatment Plant	Çubuk and Karaköy After Waste Water Treatment Plant
pH	7.7	7.25	8.42	7.475
BOD5	21	42.5	12.60	31.75
NH4 -N (mg/l)	3.855	3.585	3.52	3.72
P04 (mg/l)	0.075	0.08	0.170	0.0775

The comparison of the pollution parameters of Ankara Stream. The continuation of Çubuk Stream with our analysis is shown in Table 7 [17].

TABLE 7. Average annual values of some physical and chemical parameters of Ankara Stream and Çubuk Stream before and after the establishment of the wastewater plant

Control Parameters	Çubuk and Karaköy Before the Waste Water Treatment Plant Opens	Çubuk and Karaköy After the Waste Water Treatment Plant Opens
pH	7.35	7.7
EC µS/cm	922	941
NH4 -N (mg/l)	8.55	3.585
Cl (µg/L)	76.65	90.5
NO2 –N (mg/l)	0.0525	0.450
BOD5	39	22.5
PO4 (mg/l)	3.65	0.0775

The average values of the physical and chemical parameters of the water samples taken in different seasons of Çubuk Stream in 2012 and 2013 are shown in Table 8.

TABLE 8. The median, minimum, maximum and standard deviation values of some physical and chemical properties according to the water samples taken from the Çubuk Stream in 2012-2013

Control Parameters	First Station Average (Min-Max. ± Sd)	Second Station Average (Min-Mak. ± Sd)	Third Station Average (Min-Mak.±Sd)	Çubuk Stream Average (Min-Mak.±Sd)
EC µS/cm	298.5 (258-319 ± 29.6)	941 (916-1247 ± 158.7)	1134 (1092-1256 ± 75.4)	941 (258-1256 ± 404.14)
pH	7.85 (7.75-8.04 ± 0.12)	7.7 (7.17-7.72 ± 0.268)	7.25 (7.11-7.51 ± 0.171)	7.7 (7.11-8.04 ± 0.309)
BOD5	8.5 (8-15 ± 3.36)	22.5 (18-29 ± 4.69)	42.5 (40-47 ± 3.55)	22.5 (8-47 ± 14.61)
B (µg/L)	0.1 (0.09-0.12 ± 0.12)	0.145 (0.13-8.5 ± 4.18)	0.19 (0.17-0.31 ± 0.066)	0.145 (0.09-8.5 ± 2.41)

Control Parameters	First Station Average (Min-Max. ± Sd)	Second Station Average (Min-Mak. ± Sd)	Third Station Average (Min-Mak.±Sd)	Çubuk Stream Average (Min-Mak.±Sd)
P04 -P (mg/l)	0.07 (0.06-0.075 ± 0.006)	0.075 (0.07-0.09 ± 0.01)	0.08 (0.07-0.09 ± 0.011)	0.075 (0.06-0.09 ± 0.009)
$SO4^{=}$ (mg/l)	44.81 (14.02-130.2 ± 55.2)	59.95 (36.3-141.1 ± 49)	100.75 (82.4-132.2 ± 22)	82.05 (14.2-141.1 ± 44.8)
S (mg/l)	0.035 (0.03-0.035 ± 0.005)	0.08 (0.02-0.28. ± 0.123)	1.525 (0.03-10.05 ± 4.7)	0.035 (0.02-10.05 ± 2.93)
CN^{-} (µg/L)	0.006 (0.005-0.02 ± 0.007)	0.006 (0.003-0.02 ± 0.1)	0.008 (0.004-0.03 ± 0.1)	0.006 (0.003-0.03 ± 0.01)
Zn (mg/l)	0.33 (0.24-0.39 ± 0.066)	2.475 (0.41-2.55 ± 1.04)	0.745 (0.47-0.91 ± 0.19)	0.545 (0.24-2.55 ± 0.924)
NH4 -N(mg/l)	0.5 (0.07-0.6 ± 0.24)	3.855 (0.27-3.9 ± 1.8)	3.585 (1.14-3.7 ± 1.24)	2.34 (0.07-1.8 ± 1.709)
Al (mg/l)	0.015 (0.01-0.02 ± 0.005)	0.01 (0.01-0.02 ± 0.005)	0.01 (0.01-0.01 ± 0)	0.01 (0.01-0.02 ± 0.004)
Fe (mg/l)	0.17 (0.1-0.33 ± 0.105)	0.1 (0.1-0.42 ± 0.16)	0.13 (0.1-0.6 ± 0.24)	0.12 (0.1-0.33 ± 0.162)
NO2 -N (mg/l)	0.045 (0.03-0.06 ± 0.012)	0.44 (0.01-0.59 ± 0.265)	0.02 (0.01-0.02 ± 0.005)	0.035 (0.01-0.59 ± 0.217)
NO3 -N(mg/l)	0.25 (0.1-1.6 ± 0.714)	2.8 (1-3.4 ± 1.06)	0.85 (0.1-1.4 ± 0.535)	0.95 (0.1-3.4 ± 1.16)
Cl^{-} (mg/l)	13 (10-21 ± 4.99)	90.5 (62-204 ± 63.24)	98 (85-136 ±22.27)	84 (10-204 ± 58.08)
F^{-} (mg/l)	0.175 (0.01-0.26 ± 0.12)	0.23 (0.11-0.29 ± 0.077)	0.1 (0.07-0.1 ± 0.015)	0.105 (0.01-0.29 ± 0.091)
°F (Fr)	10.005 (0.01-20 ± 11.5)	16.005 (0.01-32 ± 18.46)	15.005 (0.01-30 ± 17.31)	10.005 (0.01-32 ± 14.78)
Cu (µg/L)	0.025 (0.01-0.87 ± 0.425)	0.01 (0.01-0.144 ± 0.06)	0.01 (0.01-0.31 ± 0.15)	0.01 (0.01-0.87 ± 0.252)
Pb (µg/L)	0.065 (0.04-0.25 ± 0.099)	0.05 (0.026-0.25 ± 0.11)	0.232 (0.144-0.87 ± 0.3)	0.117 (0.026-0.87 ± 0.26)
Cd (µg/L)	0.1 (0.02-0.1 ± 0.04)	0.1(0.02-0.1 ± 0.04)	0.065 (0.01-0.1 ± 0.046)	0.1 (0.01-0.1 ± 0.039)
Cr (µg/L)	0.02 (0.01-0.12 ± 0.051)	0.02 (0.02-0.38 ± 0.18)	0.025 (0.02-0.44 ± 0.208)	0.02 (0.01-0.44 ± 0.151)
Ni (µg/L)	0.12 (0.1-0.46 ± 0.173)	0.12 (0.11-0.34 ± 0.111)	0.12 (0.11-0.74 ± 0.311)	0.12 (0.1-0.74 ± 0.2001)
Mn (mg/l)	0.02 (0.02-0.74 ± 0.36)	0.06 (0.05-0.34 ± 0.14)	0.02 (0.02-0.46 ± 0.22)	0.035 (0.02-0.74 ± 0.235)

The average electrical conductivity of Çubuk Stream varies according to the stations in 2012-2013 (Table 8). The first station Çubuk 2 Dam was measured at EC: 298.5 µS/cm. In terms of this feature, I. class quality water shows characteristics. In the sample taken from the 2nd station, Saray-Esenboğa Road. EC was measured as 941 µS/cm. According to this value this station III. class water quality feature. The EC was measured as 1134µS/cm in the water sample taken from the 3rd station Keçiören-Hasköy region. According to this feature, this station III. class water quality.

The average EC of Çubuk Stream is 941 µS/cm. According to the average EC, Çubuk Stream II. class water quality characteristics. It has been observed that there are agricultural areas and greenhouse cultivation around the water sample areas taken from Çubuk Stream (Figure 1). Çubuk Stream, which is used as irrigation water in these areas. is classified as salty waters according to the average value of EC (EC:941) (C3 class EC: 750-2250).

According to SWQR, surface waters with pH values between 6.5 and 8.5 do not pose a problem in pollution (Figure 2).

BOD_5, which is the parameter that gives information about the oxygen amount in water quality parameters, was measured as 8.5 mg/l at the exit of the first station. Çubuk 2 Dam, in the average values of BOD_5 of the water

samples taken from the Çubuk Stream in 2012-2013. According to this value, in the quality criteria according to SWQR II. quality class water. It was measured as 22.5 mg/l at station 2 and 42.5 mg/l at station 3. According to these values, IV. quality class water (Figure 3). The average BOD of >20 in Çubuk Stream is also (22.5) IV. shows the quality class water feature.

The average Boron value of Çubuk Stream was measured as 0.145 µg/l (Figure 4). It was determined that the boron concentration was higher especially in the second station. The second station is near a food factory where boron is widely used. Boron level less than 1 µg/l is a tolerable amount in water pollution.

In Çubuk Stream phosphate values, average phosphate values of 4 months between 2012 and 2013; 1st station is 0.07 mg/l. 2nd station is 0.075 mg/l. 3rd station is 0.080 mg/l. The average annual value of the three stations is 0.075 mg/l. In addition, according to Figure 5. water samples were taken at different seasonal temperatures and the phosphate values were highest in august. when the temperature was the highest; It was observed that the temperature was lower in January when the temperature was the lowest.

The average sulfate rate of Çubuk Stream is 82.05 mg/l. Since it is lower than 200 mg/l according to this value of sulfate. it has class I water quality (SWQR, 2015). In addition, according to Figure 6. the water samples were taken at different seasonal temperatures and the sulfate values were highest in august. when the temperature was the highest.

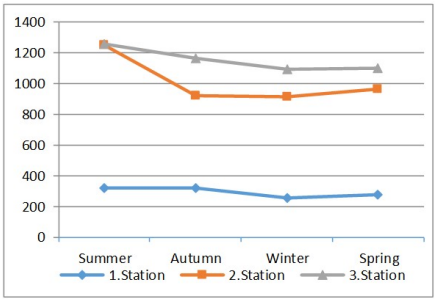

FIGURE 1. Çubuk Stream EC values

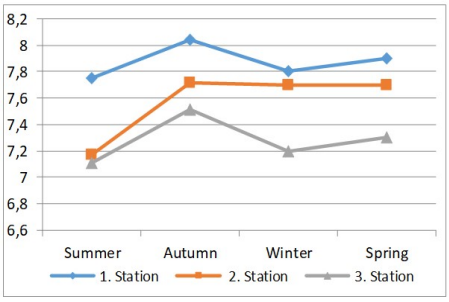

FIGURE 2. Çubuk Stream pH values

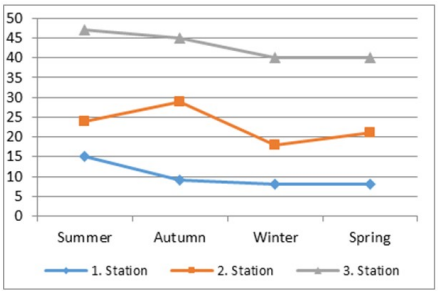

FIGURE 3. Çubuk Stream BOD5 values

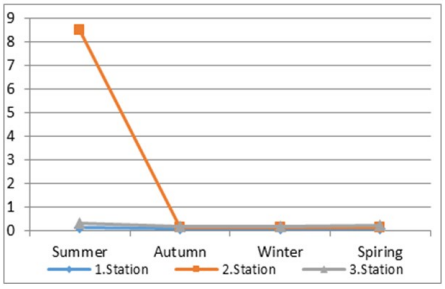

FIGURE 4. Çubuk Stream Boron values

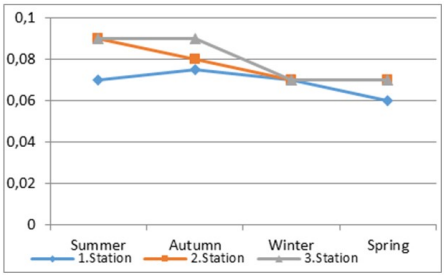

FIGURE 5. Çubuk Stream PO_4^{-3} values

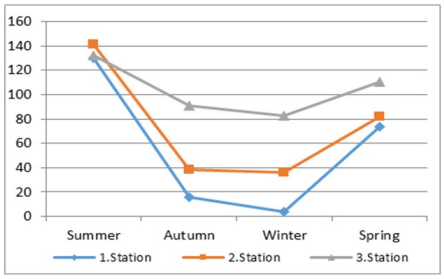

FIGURE 6. Çubuk Stream S^{-2} values

The toxicity of cyanide increases 2-3 times with every 10˚C increase in temperature [18]. According to Figure 7. the cyanide value is at a high level in the coldest winter season. The average cyanide rate in Çubuk Stream is 0.006 µg/l.

The average zinc ratio in the measurement made in Çubuk Stream is 0.545 mg/l. In terms of this parameter. Çubuk Stream is III. class water quality. According to Figure 8. it is seen that the zinc value is at a high level in the autumn and winter seasons when the air temperature is low.

The average zinc ratio in the measurement made in Çubuk Stream is 0.01 mg/l. The average pH of Çubuk Stream is close to neutral. Therefore, Çubuk Stream is not under threat in terms of aluminum value. In addition, the change in the aluminum value of Çubuk Stream depending on the seasonal temperature is shown in Figure 9.

Among the stations selected in Çubuk Stream, it was measured that the 3rd station region where the densest industrial area is located was higher than the other stations (average Fe: 0.13 mg/l at the 3rd station; average Fe: 0.1 mg/l

at the 2nd station; 1st station average Fe: 0.17 mg/l). The average Fe value of Çubuk Stream is 0.12 mg/l. Since the Fe value is less than 0.3 mg/l according to SWQR it has I. class quality water standards. Figure 10. shows the variation of iron ratio according to seasonal temperature.

Average ammonium values of 3 months taken between 2012 and 2013; 1st station is 0.5 mg/l. 2nd station is 3.855 mg/l. 3rd station is 3.585 mg/l. It is seen that the ammonium value is at the highest value according to Figure 11.

Nitrite values in this study we have done about Çubuk Stream: Average nitrite values of 4 months taken between 2012 and 2013; 1st station is 0.045 mg/l. 2nd station is 0.44 mg/l. 3rd station is 0.02 mg/l. The variation of nitrite values depending on seasonal temperature is shown in Figure 12. According to SWQR the average nitrite concentration is 0.035 mg/l. in terms of this parameter II. class water quality.

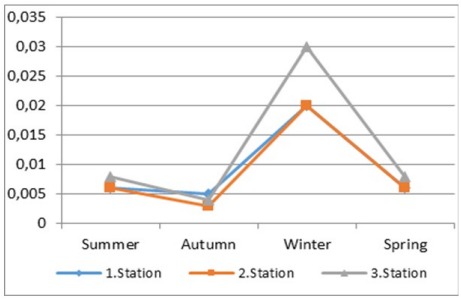

FIGURE 7. Çubuk Stream CN values

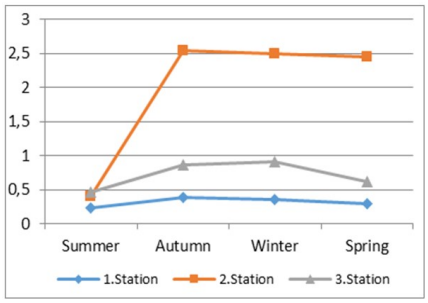

FIGURE 8. Çubuk Stream Zn values

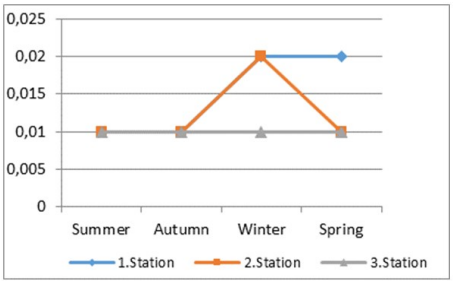

FIGURE 9. Çubuk Stream Al values

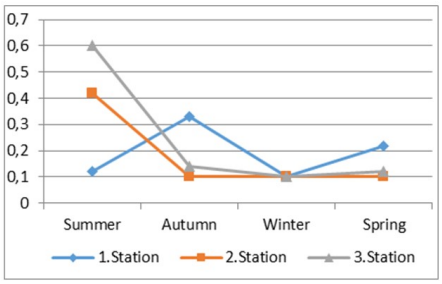

FIGURE 10. Çubuk Stream Fe values

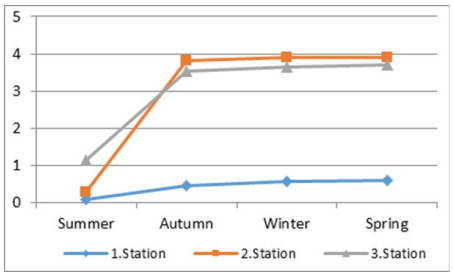

FIGURE 11. Çubuk Stream NH_4^+ values

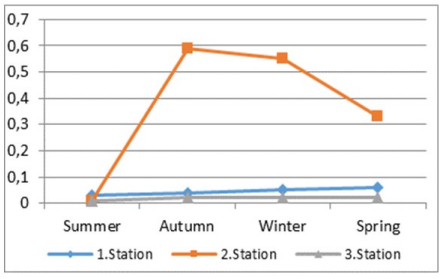

FIGURE 12. Çubuk Stream NO_2^- values

The average nitrate level in Çubuk Stream was 1.283 mg/l. Especially, the nitrate concentration in the 2nd station area is higher than the other two stations (2nd station average nitrate value: 2.5 mg/l; 1st station average nitrate value: 0.55 mg/l; 3rd station average nitrate value: 0.8 mg/l). In addition, in the measurements made during the sampling from the 2nd station region macroscopically mossy layers were observed on the water surface in this region. We can say that there is water pollution due to eutrophication in the 2nd station area.

In Çubuk Stream, average nitrate values of 4 months taken between 2012 and 2013; 1st station is 0.25 mg/l. 2nd station is 2.8 mg/l. 3rd station is 0.85 mg/l. The variation of nitrate values depending on seasonal temperature is shown in Figure 13. As shown in Table 5 the average nitrate concentration of 0.95 mg/l according to the SWQR values indicates class I water quality in terms of this parameter.

As a result of the measurements made in Çubuk Stream, the average Cl^- ions were measured as 13 mg/l at the 1st station, 90.5 mg/l at the 2nd station, and 98 mg/l at the 3rd station. These values show direct proportion with EC. According to Figure 14, it is seen that the chloride value is high in the summer season when the temperature is high and the precipitation is low. In areas used as irrigation water. The amount of chloride should be kept under control. High chloride concentration damages many trees and plants [18]. The average value of the chloride ion (84 mg/l) less than 200 mg/l shows I. class water quality according to SWQR.

The average fluoride value measured in Çubuk Stream is 0.105 mg/l. The 0.23 mg/l fluoride rate should be controlled. Especially in the industrial areas where agricultural areas are concentrated and Çubuk Stream is used as irrigation water in the second station area which is dense. The variation of fluoride values depending on seasonal temperature is shown in Figure 15.

Clay soils and areas that will be irrigated for less than 20 years should be preferred when using the analyzed regions in Çubuk Stream as irrigation water. In addition, the variation of copper values depending on seasonal temperature is shown in Figure 16.

The average lead value in Çubuk Stream is 0.117. It can be said that this environment is not conducive to the survival of sensitive macro organisms. The variation of lead values depending on the seasonal temperature is shown in Figure 17.

The fact that the cadmium values were measured as <0.1 in all three stations selected from the Çubuk Stream shows that there is a water value with acceptable standards in terms of this parameter. The variation of cadmium values depending on seasonal temperature is shown in Figure 18.

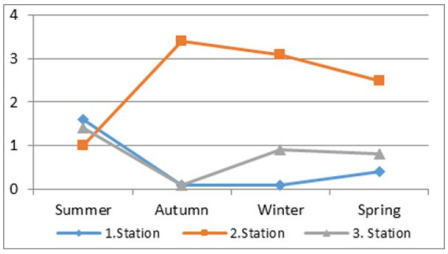

FIGURE 13. Çubuk Stream NO_3^- values

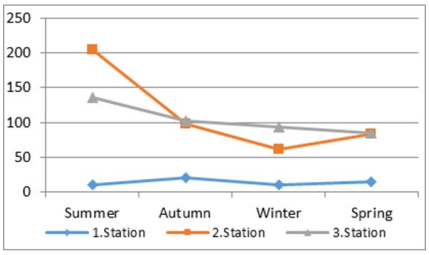

FIGURE 14. Çubuk Stream Cl^- values

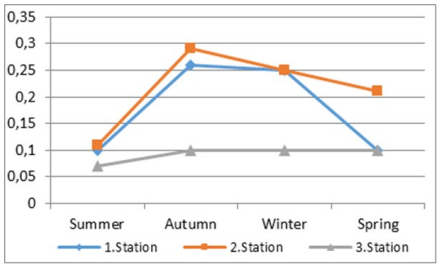

FIGURE 15. Çubuk Stream F^- values

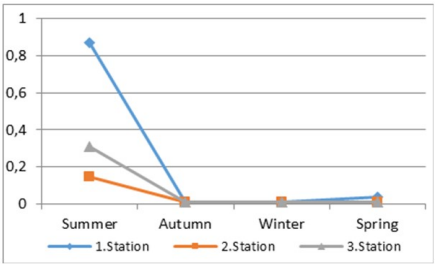

FIGURE 16. Çubuk Stream Cu values

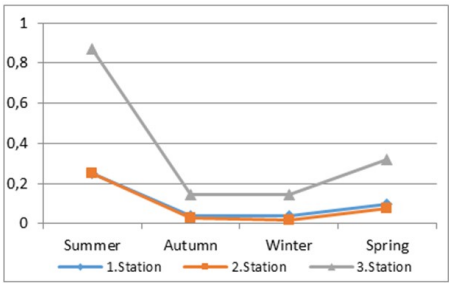

FIGURE 17. Çubuk Stream Pb values

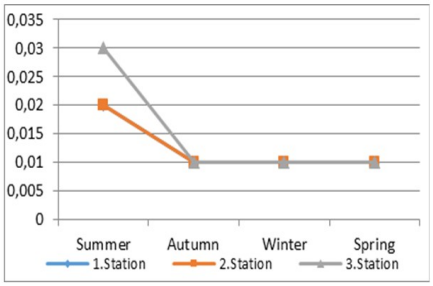

FIGURE 18. Çubuk Stream Cd values

The average chromium value of Çubuk Stream was measured as 0.1 µg/l. It can be said that this value will not adversely affect the activities of organisms in Çubuk Stream. According to Figure 19 it is seen that the chromium value is also high in the summer season when the seasonal temperature is the highest.

The average concentration of nickel in Çubuk Stream is 0.12 µg/l. This ratio shows that nickel will not harm the aquatic ecosystem. According to Figure 20 it is seen that the nickel value is high in the summer season when the seasonal temperature is the highest.

The average manganese density of Çubuk Stream is 0.035 mg/l. In terms of this ratio manganese cannot be considered to be harmful when used as irrigation water and considering the vital activities of other microorganisms in Çubuk Stream. According to Figure 21 it is seen that the manganese value is high in the summer season when the seasonal temperature is the highest.

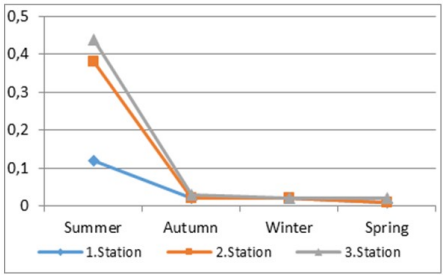

FIGURE 19. Çubuk Stream Cr values

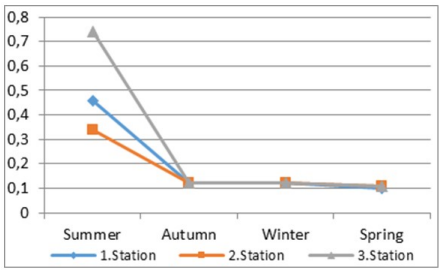

FIGURE 20. Çubuk Stream Ni values

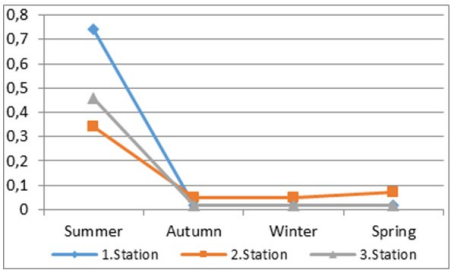

FIGURE 21. Çubuk Stream Manganese values

4. CONCLUSIONS AND DISCUSSION

According to the data obtained there are differences in the quality of Çubuk Stream during 2012-2013. These differences are mostly due to seasonal factors such as precipitation heat and temperature. In Çubuk Stream has been determined that it is polluting in terms of electrical conductivity and chlorine by looking at the average values of some physical and chemical properties. EC and Cl depend on the amount of dissolved substance in the water [20]. At the 3rd station EC and Cl parameters are in class 4 water quality according to SWQR there are greenhouse zones near this station. Compared to works [21] it is seen that there is a decrease in the sulfate rate in Çubuk Stream. The mixing of domestic and industrial wastewater into the surface waters increases the salt content of sulfate in the water. Especially when they are used as irrigation water they will adversely affect the soil and therefore the plant community in that region. Growing salt-tolerant plants in these regions provides healthier agricultural production. Water with this feature. which is used as irrigation water, is used in soils with medium and good permeability. In addition, regular soil washing programs should be followed to prevent salt accumulation in these soils.

Its pH was measured at 7.7 compared to works [16-21] with previous studies it has been determined that pH approaches neutral values over time (Table 6 and Table 7). The fact that the pH is at basic values increases the eutrophication event that causes water pollution [5]. The fact that Çubuk Stream reached a neutral value over time compared to the water samples taken in 2012-2013 suggests that eutrophication may have decreased.

According to SWQR, in terms of BOD_5 parameter it is IV class water quality. When studies in similar locations were compared according to works [16-21] an increase was found in the values for the BOD_5 parameter.

This increase may adversely affect the aerobic organisms in the water. It can also inhibit the completion of nitrification. When the previous studies are compared according to [17] a decrease in the values has been detected Ankara Stream the continuation of Çubuk Stream may have been exposed to more pollutants.

The average sulfur value measured in Çubuk Stream is 0.035 mg/l (Figure 7). Based on stations the region where the industrial zone and houses are most concentrated is the 3rd station. Considering that this station is exposed to domestic and industrial pollution at a higher rate than the other two stations it has an above-average sulfur content.

As a result of the measurements, it was determined that the ammonium concentration of the 2nd and 3rd stations was higher than the 1st station. In addition, it is seen that the ammonium values at the 2nd station are higher than the ammonium values at the 1st and 3rd stations in all 3 months of the measurement. Fertilizer, nitrocellulose, leather, food, beer, water industries and slaughterhouses are industrial establishments with a high nitrogen load [20].

Station 2 is next to a food factory, this suggests the possibility that industrial waste and fertilizers, which contain abundant nitrogenous compounds may have mixed with Çubuk Stream. Due to the large number of slaughterhouses in this location, this suggests that the wastes of these slaughterhouses may have been mixed into Çubuk Stream.

The average ammonium value of Çubuk Stream is at the 2nd and 3rd stations according to SWOR, IV. class water quality, at the 1st station II. class water quality. Çubuk Stream Average ammonium value of 3 stations (2.34 mg/l) IV. class water quality. According to the previous studies [16] water which has not changed much in the NH_4-N ratio is in terms of this parameter IV class water quality. According to works [17] the value decreased from 8.55 mg/l to 3.585. The reason for this decrease may be that Çubuk Stream merges with Hatip Stream while forming Ankara Stream and nitrogen pollutants in Hatip Stream may be high.

As a result of the measurements it is seen that the average nitrite density of the 2nd station is higher than the other two stations. This may be related to the fact that the area where the slaughterhouses and industrial factories are concentrated is the 2nd station region and the waste water is discharged to Çubuk Stream. The fact that the nitrite ratio is higher than nitrate in water indicates that life is limited in aerobic conditions [7]. At the same time, according to the 2012-2013 values of Çubuk Stream, ammonium from

nitrite; the fact that the nitrite is higher than the nitrate amount proves the incomplete nitrification event. It also allows us to predict that nitrosomanas bacteria may be more than nitrobacteria in Çubuk Stream.

It was measured that the chromium value at the 3rd station was higher than the 2nd station and the 2nd station value was higher than the 1st station value. The fact that the 2nd station and 3rd station regions of the three selected stations in Çubuk Stream are industrial zones supports the possibility of these factories to discharge their wastewater into Çubuk Stream.

The amount of zinc element, which is one of the trace elements is 0.545 mg/l in Çubuk Stream. In terms of this parameter Çubuk Stream is III. class water quality, 2nd station IV class water quality. If the zinc ratio exceeds 2.0 g/l in surface waters, it may cause chlorosis problem in plants. If Çubuk Stream will be used as irrigation water in the 2nd and 3rd station regions these environments must be clayey soils [2]. According to the result, the treatment plants established close to these regions should also provide treatment to reduce the amount of heavy metals.

The amount of phosphate decreased according to some works [16]. The increase in phosphate value in surface waters causes the reproduction of organisms, especially algae, in the water [5]. With the opening of wastewater treatment plants in the region, it can be predicted that eutrophication due to the amount of phosphate will decrease.

NH_4-N/PO_4 ratio is used to determine the limiting nitrogen and phosphate elements of eutrophication [22]. If NH_4-N/PO_4 > 20, the system is restricted by phosphorus and when NH_4-N/PO_4 < 5, the system is restricted by nitrogen. According to previous studies, NH_4-N/PO_4 = 20.7; According to after studies, NH_4-N/PO_4 = 2.34; during 2012 – 2013, Çubuk Stream was measured at NH_4-N/PO_4 = 48 values. According to the 2012-2013 NH_4-N/PO_4 values and Çubuk Stream the system is limited by nitrogen. According to Atıcı and Ahıska [17] the system is limited by phosphate.

In this study on the pollution of Çubuk Stream, higher quality water can be supplied to the region with the wastewater treatment plants established in 2009. Treatment facilities were established with the aim of reducing the nitrate nitrogen and phosphate ratio in the use of Çubuk Stream as irrigation water for the region [13]. Our study result supported the confirmation of this aim. A similar study was conducted in St. Johns River (LSJR), located in Florida and the causes of pollution in rivers were determined [23], and China's Guanzhong Basin, similar studies have been carried out to see how

the emergence of the pollution load in the groundwater with the increase in population creates the results. [24].

While the 1st station was more distant from the anthropogenic effect in the 3rd stations studied. The 3rd station was more affected by this effect. Therefore, people need to be made aware of this issue. A regional public service announcement can be created regarding this. Information can be given in local newspapers. Likewise, in the 2nd station area where industrial establishments are concentrated. Inspections should be made more frequently for establishments that cause pollution. These are important for the future and sustainability of Çubuk Stream. No unexpected pollutants from chemical and physical parameters were detected in Çubuk Stream. This study is important because it will contribute to the country's economy in determining the factors that cause pollution in matters related to water pollution and will contribute to the scientific literature in studies on wastewater treatment applications.

Acknowledgement. This study is a part of the work completed as a graduate study in Gazi University Institute of Educational Sciences.

Author Contribution Statements TA-Collection and evaluation of physical and chemical data, writing of the study. DBO-Collection and evaluation of physical and chemical data, writing of the study. All authors have read and approved the manuscript.

Declaration of Competing Interests The authors declare no conflict of interest in relation to this particular article.

REFERENCES

[1] Baysal, A., Genel Beslenme Bilgisi, Hatipoğlu Yayınevi, Ankara, 1989.
[2] Atalık, A., Küresel ısınmanın su kaynakları ve tarım üzerine etkileri, *Bilim ve Ütopya,* 139 (2006), 18–21.
[3] Özgüler, H., Su, su kaynakları ve çevresel konular, Meteoroloji Mühendisliği, *TMMOB Meteoroloji Mühendisleri Odası Yayın Organı,* 2 (1997), 57–63.
[4] Akın. B., Atıcı. T., Katırcıoğlu, H., Fersin, K., Investigation of water quality on Gökçekaya Dam Lake using multivariate statistical analysis in Eskişehir-Turkey, *Environmental Earth Sciences*, 63(6) (2011), 1251–1261. Doi: 10.1007/s12665-010-0798-6.

[5] Atıcı, T., Sakarya nehri kirliliği ve algler, *Ekoloji Çevre Dergisi,* 24 (1997), 28–32.
[6] Cirik, S., Cirik, Ş. Limnoloji, Ege Üniversitesi Su Ürünleri Fakültesi Yayınları, no: 21, İzmir, 1999.
[7] Egemen, Ö., Su Kalitesi, Ege Üniversitesi Su Ürünleri Fakültesi Yayını, İzmir, 2006.
[8] Taş, B., Çetin, M., Gökgöl (Ordu-Türkiye)'ün bazı fiziko-kimyasal özelliklerinin incelenmesi, *Ordu Üniversitesi Bil. Tek. Dergisi,* 1(1) (2011), 73–82.
[9] Harper, D. Eutrophication of Fresh Waters: Principles, Problems and Restoration, Chapman and Hall., London, 1992.
[10] Tepe, Y., Boyd, C.E., A reassesment of nitrogen fertilization for sunfish ponds. *Journal of World Aquaculture Society*, 34 (4) (2003), 505–511.
[11] Shah, C.R., Which physical, chemical and biological parameters of water determine its quality? (2017), Doi:10.13140/RG.2.2.29178.90569
[12] DSİ., 52. Yıl Çalışma Raporu, Ankara, 2006.
[13] http://www.webcitation.org/query?url=http%3A%2F%2Fwww.dsi.gov.tr%2Fprojeler%2Fcubuk-Çubukaj%25C4%25B1&date=2017-12-18.
[14] SWQR, Su Kirliliği Kontrolü Yönetmeliği. Numune Alma ve Analiz Metotları Tekniği, Resmi Gazete, sayı 20748 (7 Ocak), Ankara, 1991.
[15] SWQR, Su Kirliliği Kontrol Yönetmeliği, Resmi Gazete, sayı 29327 (15 Nisan), Ankara, 2015.
[16] Yıldız, H., Uzbilek, M., Çubuk çayında (Ankara) bentik makro omurgasızların yapısı, *Tarım Bilimleri Dergisi*, 7(3) (2001), 54–57.
[17] Atıcı, T., Ahıska, S., Ankara çayı kirliliği ve algleri, *Gazi Üniv. Fen Bilimleri Enstitüsü Dergisi*, 18(1) (2005), 51–59.
[18] Atakan, Y., Çernobil Kaynaklı Radyoaktif Serpintilerinin Çevreye ve İnsana Etkileri, TÜBİTAK Yayınları, Ankara, 1994.
[19] Ünlü, A., Çoban, F., Tunç, M.S., Hazar Gölü su kalitesinin fiziksel ve inorganik-kimyasal parametreler açısından incelenmesi, *Gazi Üniversitesi Mühendislik Mimarlık Fakültesi Dergisi*, 23(1) (2008), 119–127.
[20] Topbaş, T.M., Brohi, A.R., Karaman, M.R., Çevre Kirliliği, T.C. Çevre Bakanlığı Yayınları, Ankara, 1998.
[21] Sungur, D., Yıldız. K., Çubuk stream Bacillariophyta dışındaki algleri, *G.Ü. Fen Bilimleri Enstitüsü Dergisi,*11(2) (1998), 249–264.
[22] Shelknanloymilan, L., Atıcı, T., Obalı, O., Removal of nitrogen and phosphate by using Choleralla vulgaris on synthetic and organic materials waste water, *Biological Diversity and Conservation*, 5(2) (2012), 89–94.
[23] Ouyang, Y., Evaluation of river water quality monitoring stations by principal component analysis, *Water Research,* 39 (2005), 2621–2635.
[24] Gao, Y., Qian, H., Ren, W, Wang, Liu, F. Yang, F. Hydrogeochemical characterization and quality assessment of groundwater based on integrated-weight water quality index in a concentrated urban area, *Journal of Cleaner Production,* 260 (2020). Doi: 10.1016/j.jclepro.2020.121006.