Araştırma Makalesi
(Research Article)

Ege Üniv. Ziraat Fak. Derg., 2017, 54 (3):249-257
ISSN 1018 – 8851

Saliha DORAK
Hakan ÇELİK

Uludag University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, 16059, Bursa/Turkey
corresponding author:hcelik@uludag.edu.tr

Irrigation Water Quality of Nilüfer Stream and Effects of the Wastewater Discharges of the Treatment Plants

Nilüfer Çayının Sulama Suyu Kalitesi ve Arıtma Tesisleri Atıksularının Etkileri

Alınış (Received): 20.01.2017 Kabul tarihi (Accepted): 28.02.2017

Key Words:

Resudial sodium carbonate, sodium adsorption ratio, wastewater discharge, water pollution

ABSTRACT

In this research, the aim is to determine the irrigation water quality parameters of Nilüfer stream which is the most important irrigation water resource of Bursa and also the wastewater discharge point of many water treatment plants. Water samples were taken at four different periods between August 2013-May 2014 from the starting point of the five treatment plants that discharge to Nilüfer stream and from the stream which the treatment plants discharge to. The pH (7.04 – 9.43), EC (0.36 – 6.75 mS cm^{-1}), temperature (10.7 – 32.9°C), ammonium-N (trace – 86.73 mg l^{-1}), nitrate - N (trace – 19.33 mg l^{-1}), phosphorus (0 – 10.68 mg l^{-1}), Boron (0 – 3.85 mg l^{-1}), sulfate (4.1 – 325.8 mg l^{-1}), chlorine (7.09 – 857.9 mg l^{-1}) amounts were determined and also the Residual Sodium Carbonate (RSC) (trace – 44.02 me l^{-1}) and Sodium Adsorption Ratio (SAR) (0.20 – 37.15) were calculated respectively. Wastewater samples were classified between C_2S_1-C_4S_4 according to the EC and Sodium Adsorption Ratio (SAR) values. Treatment plants wastewater discharges vary due to the periods and negatively affected pH, EC, ammonium, phosphorus, sulfate, boron and chlorine contents of the Nilüfer stream.

Anahtar Sözcükler:

Bakiye sodyum karbonat, sodyum adsorbsiyon oranı, atık su deşarjı, su kirliliği

ÖZET

Bu çalışmada amaç, pek çok tesisin arıtma sularının deşarj yeri olan ve aynı zamanda Bursa ilinin tarımsal sulama suyu kaynağının büyük bir kısmını oluşturan Nilüfer Çayı'nın sulama suyu kalite parametrelerinin belirlenmesidir. Nilüfer Çayı'na deşarj eden 5 arıtma tesisinin çıkış noktasından ve bu tesislerin deşarj ettikleri derelerden Ağustos 2013–Mayıs 2014 tarihleri arasında 4 farklı dönemde atık su örnekleri alınmıştır. pH (7.04 – 9.43), EC (0.36 – 6.75 mS cm^{-1}), sıcaklık (10.7 – 32.9 °C), Amonyum-N (iz – 86.73 mg l^{-1}), Nitrat – N (iz – 19.33 mg l^{-1}), Fosfor (0 – 10.68 mg l^{-1}), Bor (0 – 3.85 mg l^{-1}), sülfat (4.1 – 325.8 mg l^{-1}), klor (7.09 – 857.9 mg l^{-1}) değerleri belirlenmiş, aynı zamanda bakiye sodyum karbonat (RSC) (iz – 44.02 me l^{-1}) ve sodyum adsorbsiyon oranları (SAR) (0.20 – 37.15) hesaplanmıştır. EC ve SAR değerleri dikkate alınarak yapılan sınıflandırmaya göre su örneklerinin C_2S_1-C_4S_4 sınıfları arasında yer aldığı tespit edilmiştir. Nilüfer Çayı ve Nilüfer Çayı'na deşarj edilen kimi arıtma tesisleri atık su kalite parametrelerinin dönemlere göre değişiklik gösterdiği, özellikle EC, Sıcaklık, Amonyum, Nitrat, Fosfor, Sülfat ve Klor değerlerine olumsuz yönde etki ettikleri görülmüştür.

INTRODUCTION

Nowadays, against the rapidly increasing human population, the limited agricultural lands force the farmers, to produce much more and better quality products per unit area. For the realization of this purpose, plant's water and nutrient element needs must be supplied in an optimum way. By the way, irrigation water and the fertilizers are one of the main factors which increase the agricultural production (Bouman et al., 2001). All living organisms need a huge amount of water for their life, growth, and other requirements and this water is provided from surface water and underground water resources (Deng et al., 2006). Besides affecting crop yield and physical soil conditions, irrigation water quality can also affect fertility needs, on performance and longevity of the irrigation system and also on the application method of the water. So to know the irrigation water quality is an important factor of management procedures on the long term productivity (Bauder et al., 2014).

Since two hundred years ago, the population movements related to the fast development of industry and the intensive agricultural activities affected the natural environment and have been the main polluting factors. The quality of the irrigation water is very important for the agricultural countries which have a rapid growing population and developed countries like Turkey. The increasing concentrations of many elements in the form of ions or groups of ions contained in the water restrict or prevent the use of water for drinking, irrigation or industrial purpose. Water containing high amounts of toxic materials which is used for irrigation without of any precautions causes to the structural degradation at the soil. Ultimately normal soils can be turned to saline and alkaline soils. Degradation of the soils by the irrigation also leads to economic problems (Bouwer, 2000).

Among the inexhaustible natural resources; soils and water, forms the bases of the nation's wealth. The existence of the soil and to know the potential of water resources and its quality is important for the preparation of the plans and programs for the amounts of water usage. Therefore, it is important to know the foreign material concentrations of the irrigation water and using it after taking precautions (Breś et al., 2010). At the first period of the intense urbanization of the industrial revolution, it is believed that the nature has an ability to hide or have an infinite treatment power for all of the pollutants. But the pollutants have started to negatively affect nature and living things. So some studies have been initiated to determine, understand and take precautions against pollutants (Ashraff et al., 2010). Taking periodical water samples and making chemical analysis of these samples are the important parts of these studies.

Bursa is the fourth biggest and is also known as an important agricultural and industrial city of Turkey. In recent years, there has been an important increase at the population of the city because of the migration. This situation has resulted in expansion of the construction of residential areas and subsequently resulted in decrease of productive agricultural lands and this also caused an increase in lots of waste materials. The Nilüfer stream, which is approximately 168 km long, is the main water resource of Bursa and has several tributaries. It supplies drinking water and irrigation water for the agricultural sites around. The Nilüfer stream basin covers 1540 km^2. More than 53.8 % of the basin is used for agricultural purposes (Karaer and Küçükballı, 2006; Üstün et al., 2008). It is not only important for agricultural lands but also is important for being the main discharge point of wastewater (Yalılı and Solmaz, 2004). The stream is known as a convenient place to discharge industrial plant wastewaters (Anonymous, 2007). In recent years, it was discovered that it is polluted by organic and inorganic pollutants because of wastewater discharges of industrial and domestic wastes. Especially in summer season, sewage flow increases because of the water reduction in the tributaries. This situation affects the water quality, causes damages to the stream and environment and leads to health problems (Üstün et al., 2008; Kocaer and Başkaya, 2004; Güleryüz et al., 2008; Üstün 2011).

In this research; the aim is to determine the irrigation water quality of the Nilüfer stream and wastewater treatment facilities which discharge to this stream in a year time period. For this purpose water samples were taken from Nilüfer stream and also from wastewater treatment plants and the irrigation water quality classes were determined and compared with the water pollution control regulation and National Inland Water Resources Quality Standards (NIWQS) (Şener and Güneş, 2015).

MATERIAL and METHOD

Material

The main materials of the research are Nilüfer stream in Bursa which is located in the north western Anatolian Region (40°11' N latitude and 29°04' E longitude) and some wastewater treatment plants which discharge to this stream.

Method

To determine the quality class of the Nilüfer stream, some water samples were collected from the determined sampling points of Nilüfer stream and wastewater treatment plants at four periods (P1: summer - August 2013; P2: fall - November 2013; P3: winter - February 2014; P4: spring - May 2014). Water sampling points and their abbreviations used in the research were shown at Figure 1 and Table 1.

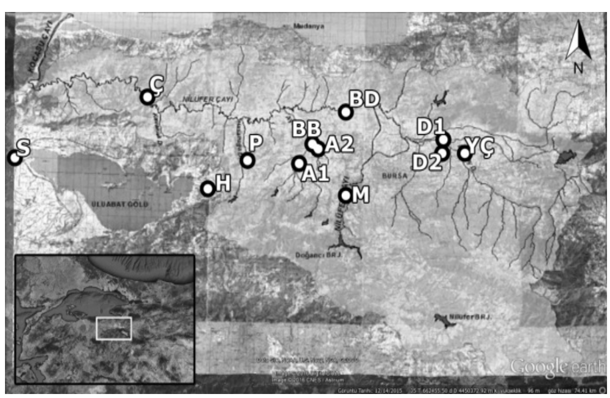


Figure 1. Sampling points.

Table 1. Sampling points and abbreviations

No	Sampling Point	Abbreviation
	Wastewater treatment plants	
1	Sütaş Dairy Inc. Water Treatment Plant	S
2	Penquen Food Industry Inc. Treatment Plant	P
3	S.S.Yeşil Environmental Treatment Plant	YÇ
4	Buski East Wastewater Treatment Plant	BD
5	Buski West Wastewater Treatment Plant	BB
	Streams	
6	Çayönü village	Ç
7	Ayvalı stream 1st point	A1
8	Ayvalı stream 2nd point	A2
9	Hasanağa stream	H
10	Misi stream	M
11	Deliçay stream 1st point	D1
12	Deliçay stream 2nd point	D2

Water samples were collected from mid-point of the stream at a depth of 15-20 cm in 1000 mL polyethylene bottles. Sampling bottles which had been washed previously with the sampling water were then filled with the water to the upper point of the bottle. At the sampling point, the pH measurements were done with WTW pH 320 model pH meter. Electrical conductivity and the temperature were measured with WTW LF 320 model conductivity meter. Collected samples were arrived to the laboratory and divided in to two groups. First group of the samples were used for analysis, chlorine analysis of the samples were done immediately and whole of the analysis were completed within two days. Second group of the samples were protected at +4°C in the refrigerator until analysis were done, to prevent the microorganism development 1-2 drops of chloroform were added to these samples (Parsons, 2013). Carbonate and bicarbonate amounts were determined with H_2SO_4 titration method by using the phenolphthalein and methyl orange reagents. Chlorine contents were determined with $AgNO_3$ titration method. Sulfate amounts were determined turbidimetrically by using $BaCl_2$. Nitrate-N and ammonium-N amounts were determined as colorimetrically, phosphorus amounts were determined by molibdophosphoric method (Mussa et al., 2009) and boron by Azomethine-H method (Jones and Benton, 2001). Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) parameters were also determined and the amounts were compared with the critical values of water pollution control regulations presented at the official newspaper 13/2/2008-26786 (Şener and Güneş, 2015).

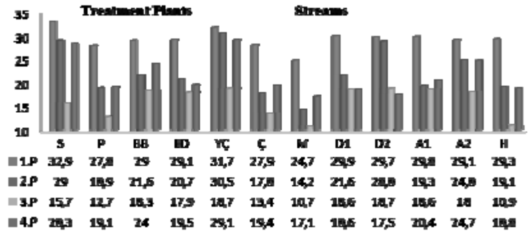
RESULTS and DISCUSSION

The analyses results of the water samples taken from the tributaries of Nilüfer stream and from the discharge points of wastewater treatment plants are shown on Figure 2 and the irrigation water classifications are shown on Table 2.

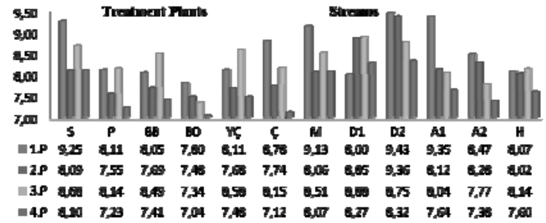
The values obtained from the analysis results differ according to the sources from which the samples were taken and also changes according to the sampling periods. These differences were related with climate, type and amount of precipitation, type of the products processed at the plants and also discharged points. The water quality problems experienced by the stream also attributed to the direct discharges of domestic and industrial wastewaters, especially in the summer periods when the stream is mostly dominated by wastewater discharges (Üstün, 2011).

Temperatures of the water samples were measured between 10.7 °C – 32.9 °C and classified in classes I. - IV. During the summer season the temperatures of the water samples were found higher than the values measured in winter season where values also shown no danger in using the waters for irrigation. The pH values were found to be between 7.04 – 9.43 and ranged within the I. - IV. classes. Changes on the pH values of the waters depended on the activities such as photosynthesis, respiration, soluble or precipitated $CaCO_3$ amounts, increase or decrease on the levels of CO_2. High pH values affect the biodiversity in the water and also it affects the solubility and accumulation of some of the elements in the soil in case they irrigated with these waters. Less soluble plant nutrients in the soil leads to the deficiencies in plants and are related with the low uptake and accumulation of heavy metals that may lead to soil pollution (Sellamuthu et al., 2011).

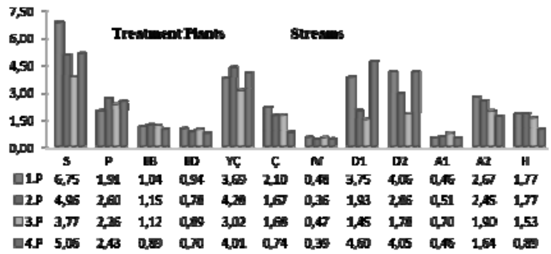
Electrical conductivity (EC) values varied between 0.36 mS cm^{-1} – 6.75 mS cm^{-1} and were between classes I. - IV. EC values of the samples taken from wastewater treatment plants such as S, P and YÇ were found higher than those obtained in samples taken from streams and this was related with the quality of the discharged waters which was used in the product processing of cheese, canned food and textile. Because of these high salts contained in the wastewater, high EC values were obtained at the streams which have discharge points of the treatment plants. The EC values of stream A1 and M were found lower than the other streams and this was related to the absence of factories and treatment plants and also related with the absence of discharge points around them. EC values of the samples taken from the streams which have discharge points were found lower than the samples taken from treatment plants. This situation could be from the dilution effect of the precipitations.



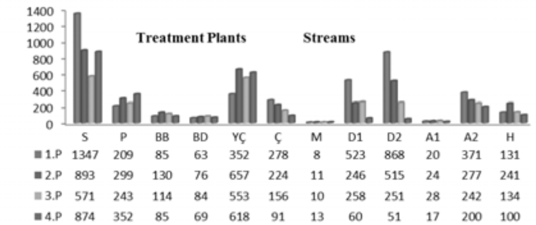
Temperature (°C)



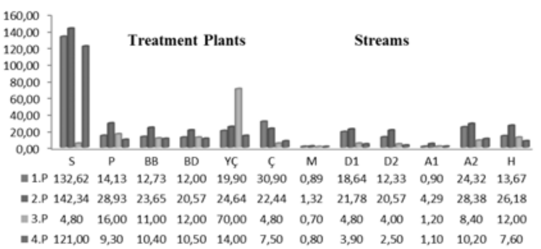
pH



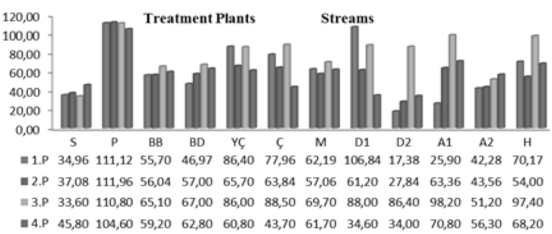
Electrical Conductivity (mS cm^{-1})



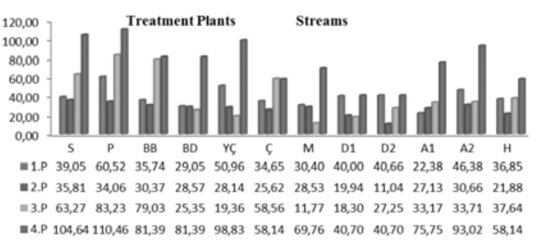
Na (mg l^{-1})



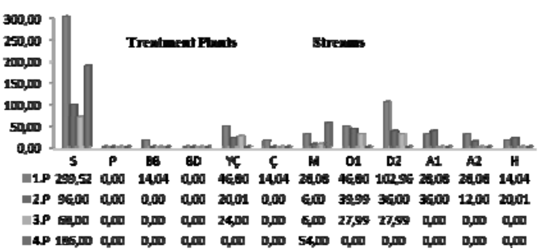
Potassium (mg l^{-1})



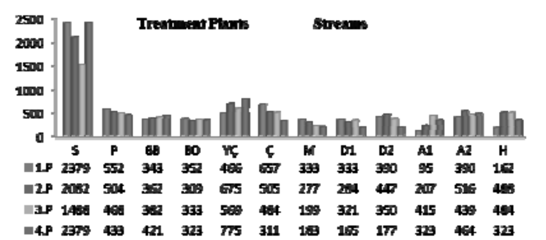
Calcium (mg l^{-1})



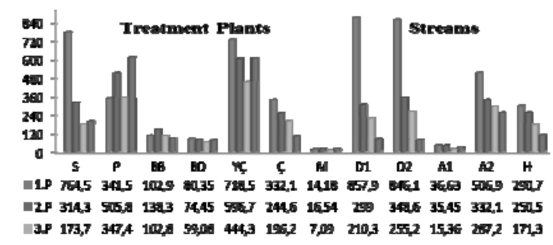
Magnesium (mg l^{-1})



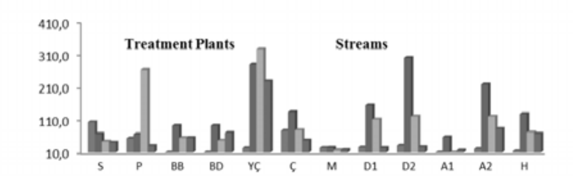
Carbonate (mg l^{-1})



Bicarbonate (mg l^{-1})

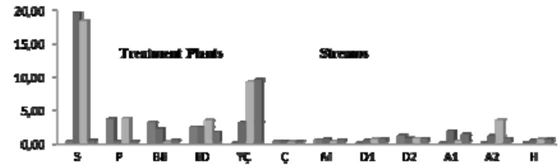


Chlorine (mg l^{-1})



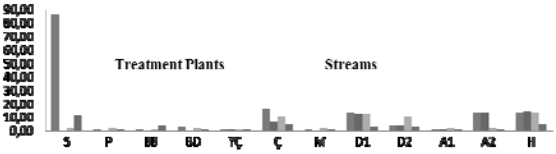
	S	P	BB	BD	YÇ	Ç	M	D1	D2	A1	A2	H
1.P	102,8	53,1	8,5	7,1	23,4	77,0	24,3	25,8	31,0	4,1	21,3	14,2
2.P	66,8	66,0	92,1	92,1	278,8	134,0	24,9	154,1	299,3	56,9	218,4	127,9
3.P	43,7	262,6	54,6	46,7	325,8	78,7	17,4	111,5	120,6	9,1	120,5	71,9
4.P	40,3	30,2	54,7	70,5	228,0	47,3	17,9	24,1	26,7	16,6	82,7	67,4

Sulphate (mg l^{-1})



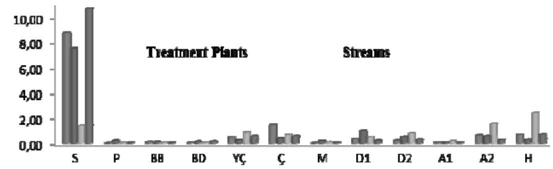
	S	P	BB	BD	YÇ	Ç	M	D1	D2	A1	A2	H
1.P	0,19	3,50	2,98	2,28	0,00	0,20	0,42	0,00	1,07	0,00	0,00	0,00
2.P	19,33	0,23	2,00	2,26	2,98	0,20	0,55	0,39	0,67	1,66	1,05	0,39
3.P	18,12	3,56	0,08	3,30	9,07	0,10	0,20	0,53	0,64	0,23	3,32	0,51
4.P	0,30	0,18	0,36	1,47	9,39	0,16	0,38	0,57	0,64	1,17	0,64	0,50

Nitrate-N (mg l^{-1})



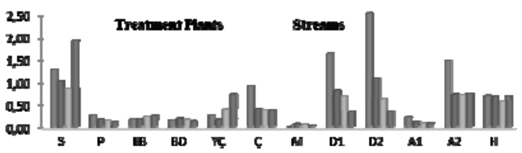
	S	P	BB	BD	YÇ	Ç	M	D1	D2	A1	A2	H
1.P	86,73	0,01	0,20	2,79	0,23	16,20	0,03	12,93	3,44	0,40	13,04	12,93
2.P	0,00	0,00	0,00	0,00	1,35	6,65	0,00	12,13	4,22	1,18	13,40	14,74
3.P	1,81	1,61	1,38	1,54	0,81	10,40	1,81	11,95	10,13	1,49	1,54	13,56
4.P	11,40	0,14	4,06	0,23	0,83	4,43	0,18	2,49	3,32	0,55	0,69	5,03

Ammonium-N (mg l^{-1})



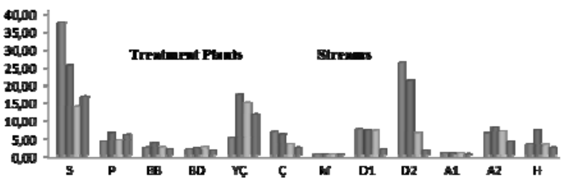
	S	P	BB	BD	YÇ	Ç	M	D1	D2	A1	A2	H
1.P	8,74	0,00	0,10	0,04	0,48	1,46	0,00	0,34	0,21	0,06	0,62	0,68
2.P	7,49	0,20	0,12	0,14	0,26	0,38	0,18	0,98	0,50	0,07	0,55	0,29
3.P	1,39	0,05	0,06	0,06	0,85	0,67	0,09	0,49	0,78	0,18	1,56	2,42
4.P	10,68	0,03	0,04	0,14	0,56	0,56	0,06	0,21	0,30	0,06	0,28	0,71

Phosphorus (mg l^{-1})



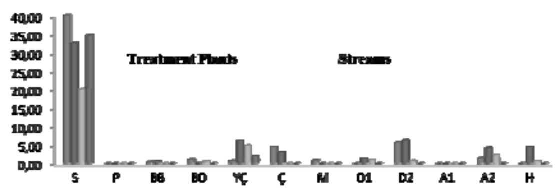
	S	P	BB	BD	YÇ	Ç	M	D1	D2	A1	A2	H
1.P	1,25	0,25	0,16	0,14	0,25	0,90	0,00	1,60	3,85	0,21	1,46	0,68
2.P	0,99	0,16	0,17	0,18	0,16	0,39	0,06	0,80	1,06	0,10	0,71	0,67
3.P	0,84	0,14	0,22	0,15	0,38	0,37	0,04	0,67	0,60	0,07	0,70	0,55
4.P	1,90	0,10	0,24	0,12	0,71	0,36	0,02	0,33	0,34	0,07	0,73	0,67

Boron (mg l^{-1})



	S	P	BB	BD	YÇ	Ç	M	D1	D2	A1	A2	H
1. P	37,15	3,96	2,18	1,77	4,94	6,53	0,20	7,29	26,03	0,65	6,25	3,14
2. P	25,25	6,34	3,49	2,05	17,02	5,99	0,29	6,59	20,86	0,63	7,86	6,59
3. P	13,58	4,35	2,29	2,31	14,70	3,25	0,30	6,87	6,31	0,64	6,66	3,05
4. P	16,51	5,86	1,72	1,38	11,55	2,17	0,26	1,66	1,42	0,34	3,86	2,20

SAR



	S	P	BB	BD	YÇ	Ç	M	D1	D2	A1	A2	H
1.P	44,02	0,00	0,36	1,04	0,69	4,42	0,79	0,00	5,62	0,00	1,41	0,00
2.P	32,50	0,00	0,63	0,00	6,06	2,96	0,00	1,30	6,23	0,00	4,17	4,43
3.P	20,00	0,00	0,00	0,47	4,80	0,00	0,00	0,86	0,66	0,00	2,30	0,59
4.P	34,60	0,00	0,00	0,00	1,93	0,00	0,00	0,00	0,00	0,00	0,00	0,00

RSC (me l^{-1})

Figure 2. Periodical analysis results of the water samples.

Table 2. Irrigation water classifications of the water samples according to the inspected parameters.

Sampling Points	Sampling Periods	pH	EC	°C	Cl^-	$SO_4^=$	NO_3^--N	NH_4^+-N	P	B	RSC	SAR
		Treatment Plants										
S	1	**IV**	**IV**	**IV**	**IV**	I-II	I	**IV**	**IV**	**IV**	III	**IV**
	2	I-III	**IV**	III	III	I-II	III	I	**IV**	I-III	III	III
	3	III	**IV**	I-II	II	I-II	III	III	**IV**	I-III	III	II
	4	I-III	**IV**	III	II	I-II	I	**IV**	**IV**	**IV**	III	II
P	1	I-III	III	III	III	I-II	I	I	I	I-III	I	I
	2	I-III	III	I-II	**IV**	I-II	I	I	II	I-III	I	I
	3	I-III	III	I-II	III	III	I	III	II	I-III	I	I
	4	I-III	III	I-II	**IV**	I-II	I	I	II	I-III	I	I
BB	1	I-III	III	III	II	I-II	I	I	II	I-III	I	I
	2	I-III	III	I-II	II	I-II	I	I	II	I-III	I	I
	3	I-III	III	I-II	II	I-II	I	III	II	I-III	I	I
	4	I-III	II	I-II	II	I-II	I	**IV**	II	I-III	I	I
BD	1	I-III	II	III	II	I-II	I	**IV**	II	I-III	I	I
	2	I-III	II	I-II	II	I-II	I	I	II	I-III	I	I
	3	I-III	II	I-II	II	I-II	I	III	II	I-III	I	I
	4	I-III	II	I-II	II	I-II	I	II	II	I-III	I	I
YÇ	1	I-III	**IV**	**IV**	**IV**	I-II	I	II	III	I-III	I	I
	2	I-III	**IV**	**IV**	**IV**	III	I	III	III	I-III	III	II
	3	I-III	**IV**	I-II	**IV**	III	II	II	**IV**	I-III	III	II
	4	I-III	**IV**	III	**IV**	III	II	II	III	I-III	II	II
		Streams										
Ç	1	III	III	III	III	I-II	I	**IV**	**IV**	I-III	III	I
	2	I-III	III	I-II	III	I-II	I	**IV**	III	I-III	III	I
	3	I-III	III	I-II	II	I-II	I	**IV**	**IV**	I-III	I	I
	4	I-III	II	I-II	II	I-II	I	**IV**	III	I-III	I	I
M	1	**IV**	II	I-II	I	I-II	I	I	I	I-III	I	I
	2	I-III	I	I-II	I	I-II	I	I	III	I-III	I	I
	3	III	II	I-II	I	I-II	I	III	II	I-III	I	I
	4	I-III	I	I-II	I	I-II	I	I	II	I-III	I	I
D1	1	I-III	**IV**	III	**IV**	I-II	I	**IV**	III	**IV**	I	I
	2	III	III	I-II	III	I-II	I	**IV**	**IV**	I-III	II	I
	3	III	III	I-II	III	I-II	I	**IV**	III	I-III	I	I
	4	I-III	**IV**	I-II	II	I-II	I	**IV**	III	I-III	I	I
D2	1	**IV**	**IV**	III	**IV**	I-II	I	**IV**	III	**IV**	III	**IV**
	2	**IV**	III	III	III	III	I	**IV**	III	**IV**	III	III
	3	III	III	I-II	III	I-II	I	**IV**	**IV**	I-III	I	I
	4	I-III	**IV**	I-II	II	I-II	I	**IV**	III	I-III	I	I
A1	1	**IV**	II	III	II	I-II	I	II	II	I-III	I	I
	2	I-III	II	I-II	II	I-II	I	III	II	I-III	I	I
	3	I-III	II	I-II	I	I-II	I	III	III	I-III	I	I
	4	I-III	II	I-II	II	I-II	I	II	II	I-III	I	I
A2	1	I-III	III	III	**IV**	I-II	I	**IV**	III	**IV**	II	I
	2	I-III	III	I-II	III	III	I	**IV**	III	I-III	III	I
	3	I-III	II	I-II	III	I-II	I	III	**IV**	I-III	II	I
	4	I-III	II	I-II	III	I-II	I	II	III	I-III	I	I
H	1	I-III	III	III	III	I-II	I	**IV**	**IV**	I-III	I	I
	2	I-III	III	I-II	III	I-II	I	**IV**	III	I-III	III	I
	3	I-III	III	I-II	II	I-II	I	**IV**	**IV**	I-III	I	I
	4	I-III	II	I-II	II	I-II	I	**IV**	**IV**	I-III	I	I

Irrigation water having high EC value and low precipitation causes the elevation of salts in the soil. Water soluble salts especially sodium has a toxic effect on plants and physical and chemical properties of the soil and leads to degradation, salinization and alkalinization of soil (Üstün et al., 2008).

Sodium amounts were found between 8-1347 mgl^{-1}, chlorine 7.09-857.9 mg l^{-1} and classified in to classes I. - IV. High sodium amounts in the irrigation water leads to dispersion of soil aggregates. Moreover, bad structured soil types have low infiltration and percolation properties, high pH, germination difficulties of seeds and working difficulties with agricultural tools (Hopkins et al., 2007; Horneck et al., 2007). Concentration of the chlorine ion which is one of the important elements of natural waters was generally low. A high chlorine concentration is an indicator of high salinity and EC. Chlorine concentration has a direct importance on the quality of water used for drinking, industry and irrigation (Ünlü et al., 2008). Sodium chloride (NaCl) is the most naturally found chloride salt in water and is known as the dominant salt of sea water. Sodium chloride found in the irrigation water affects cultivated plants at different concentration ranges and this depends on the plants type, soil conditions and climate (Fipps, 2003). Generally, the concentration of sodium chloride in the water used for irrigation is recommended not to exceed 700 mg l^{-1} (Özbek, 1990). According to this suggestion, the waters taken from YÇ and S treatment plants and D1 and D2 were found not recommendable for use in irrigation at the first period.

NO_3- N amounts were found between trace – 19.33 mg l^{-1} and classified in classes I. - III. according to the inland water resources classification system. NH_4-N amounts of the water samples varied between 0 – 86.73 mg l^{-1}, phosphorus and boron amounts varied between 0 – 10.68 mg l^{-1}, 0 – 3.85 mg l^{-1} respectively and classified in classes I. – IV. Sulfate amounts were found between 4.1 – 325.8 mg l^{-1} and classified in classes I. – III. according to the inland water resources classification system. Nitrate which is synthesized in nitrogen cycle is naturally occurring chemical. Uslu and Turkman (1987) reported that nitrate ions in water, are related with the animals' and plants' wastes, fertilizers which contain nitrate and oxidation of nitrogen to nitrogen oxide as a result of electrical discharges in the atmosphere. There is no toxic effect of nitrate to plants which is one of the important nutrient elements of the plants and is also a desired element in the irrigation water. It was reported that in Russia and USA, there are wells which have up to 100 ppm nitrate (Özbek, 1990). Although it is less toxic than the other forms of nitrogen in the aquatic environment, such as nitrite and ammonia, nitrate can be harmful on the development of early life stages in aquatic organisms by reducing the oxygen carrying capacity of the blood (Ashraf et al., 2010). Although the concentration of the nitrate in surface water was found generally low, it could be toxic to carp when the concentration found increases over 80 mg l^{-1} (Svobodá et al., 1993).

According to the analysis results, phosphorus contents of water from some treatment plants and streams were found over the limit and chemical pollution was observed in these resources due to the high phosphorus contents. Increased levels of phosphorus with nitrogen in water lead to eutrophication and stop the aquatic life by enhancing plant and algal growth which depletes the oxygen to critical levels in water (Ashraf et al., 2010). Phosphorus is known as a polluting parameter in water and can be found naturally or as a result of bad treatment of the industrial waste. Although phosphorus is found low in unpolluted natural waters, amount of phosphate over 0.30 mg l^{-1} indicates that water is contaminated and around 0.50 mg l^{-1} values indicates extreme contamination and eutrophication (Tepe and Boyd, 2003).

Wastewaters discharges, especially from food industry and municipal wastes have high amounts of boron because of the usage of the detergents containing huge amounts of boron as borax and also the usage of fertilizers, glass industry, fly ash containing boron from coal-fired power plants and wastewater treatment plant releases increased boron concentrations to waters (Devirian and Volpe, 2003). Water samples taken from S which is dealing with food industry treatment facility had high amounts of boron. In aquatic environments, increased sulfate amount caused by various industrial wastes, agricultural activities and household wastes is an indicator of pollution. Usage of metal sulfide at the industrial factories does not only increase the concentration of the sulfate ion in water, but also darkens the color of water. Sulfur and gypsum used in the reclamation of saline and non-saline alkali soils and sulfates formed by microbial oxidation of sulfur used as pesticide, enrich the leaking wastewaters with sulfate concentration especially sodium sulfate ($NaSO_4$). So groundwater's sulfate concentration may increase with interference of such wastewater. Substantial amounts of sulfate can be added to soil and wastewater via ammonium sulfate $(NH_4)_2SO_4$ which is commonly used as a fertilizer. Therefore, sulfate concentrations of the streams became higher in 2nd and 3th periods because of the precipitations. Sulfate concentrations in natural water differ between 5 - 100 mg l^{-1} and an increase to over 250 mg l^{-1} indicates severe pollution (Öztürk and Akköz, 2014).

Potassium, calcium and magnesium concentrations of the samples were found between 0.70 – 142.34 mg l^{1}, 17.38 - 111.96 mg l^{-1}, 11.04-110.46 mg l^{-1} respectively. Carbonate and bicarbonate concentrations were found as 0 – 299.52 mg l^{-1} and 95 – 2379 mg l^{-1}. Potassium is one of the most important plant nutrients and is found in trace amounts in irrigation waters. Presence of more than a few mg l^{-1} in irrigation water can indicate pollution which could be originating from manure or other pollutants. Aksoy and Özsoy (2002) also reported the extensive use of fertilizers and pesticides as non-point pollution sources which affect water quality.

Calcium and magnesium (Ca+Mg), is used for predicting total salt and sodium damage in irrigation water. Irrigation water containing high amounts of calcium and magnesium salts reduces the danger of sodium damage. For this reason, the presence of high amounts of calcium salts in the irrigation water is a desired property because of its positive effects on physical properties of the soil; such as structure, aggregate stability and reclamation of the alkalinity. Response of the plants to calcium in the soil solution widely differs. Although the high amounts of calcium in the soil solution is rarely observed, it can affect the other ions availability very often (Sellamuthu et al., 2011). Although it is reported that in the irrigation water, concentrations of magnesium up to 24 mg l^{-1} have no negative effect to plants development and to the soil but high amounts of magnesium was determined in all wastewater treatment plants and also in the streams.

Measured RSC and SAR values differ between trace – 44.02 me l^{-1} and 0.20 – 37.15 respectively. According to the classification system, RSC classes were found between I. - III. and SAR varied between classes I. - IV. Classifications according to the EC and SAR values are shown on Table 3. Irrigation water classes of treatment plants were found between C_2S_1 - C_4S_4 and II. and IV. classes of irrigation water. The variation between classes was supposed to be related with climate, type and amount of precipitation, type of the products processed at the plants and also discharged points. EC values of the samples were found high in S because of cheese production and in YÇ because of drained fertilizers from agricultural lands and because of discharged wastes from industry.

When the parameters of water samples taken before and after discharge were evaluated, it was shown that the materials which were discharged to Nilüfer stream negatively affected some quality parameters of the streams such as pH, EC, sodium, ammonium-N, phosphorus, sulfate, boron and chlorine concentrations. These parameters were found high in the streams except M and A1, because of the discharge waters of treatment plants which have high amounts of these contaminants and also because of the drainage waters of extensive agricultural areas which were very close to these streams. In contrast, no abnormal changes were observed on the parameters of the water samples taken from M and A1 streams which were found out of the drainage area of the treatment plants.

Table 3. Irrigation water classifications, according to EC and SAR values of the water samples.

Sampling points	Sampling Periods	Classes I	II	III	IV
Treatment Plants	1			P C_3S_1	
				BB C_3S_1	S C_4S_4
				BD C_3S_1	YÇ C_4S_2
	2				P C_4S_2
				BB C_3S_1	S C_4S_4
				BD C_3S_1	YÇ C_4S_4
	3				P C_4S_1
				BB C_3S_1	S C_4S_3
				BD C_3S_1	YÇ C_4S_4
	4				P C_4S_2
			BD C_2S_1	BB C_3S_1	S C_4S_4
					YÇ C_4S_3
Streams	1		M C_2S_1	H C_3S_1	D1 C_4S_2
			A1 C_2S_1	Ç C_3S_2	A2 C_4S_2
					D2 C_4S_4
	2		M C_2S_1	Ç C_3S_1	
			A1 C_2S_1	H C_3S_2	A2 C_4S_2
				D1 C_3S_2	D2 C_4S_4
	3		M C_2S_1	Ç C_3S_1	
			A1 C_2S_1	H C_3S_1	
				D1 C_3S_2	
				A2 C_3S_2	
				D2 C_3S_1	
	4		M C_2S_1	A2 C_3S_1	D1 C_4S_1
			A1 C_2S_1	H C_3S_1	D2 C_4S_1
			Ç C_2S_1		

When compared with the other samples, better quality of the water samples taken from M and A1 are as a result of being far away from the industry. Although water quality of the other streams also increased with the precipitations, they were classified as not suitable for irrigation because of the high EC, ammonium-N and phosphorus values. Especially high pH, EC, sodium, SAR, RSC, ammonium-N and chlorine values of the wastewaters restricts the use of them as irrigation water. When compared with normal irrigation water, using this water increases the amount of these parameters, leads to salinity, degradation of the soil structure and reduces the yield (Sellamuthu et al., 2011).

CONCLUSIONS

From this study it is concluded that intensive industrial and agricultural activities around the Nilüfer stream are causing pollution and reducing the water quality of the stream therefore, it is necessary to be careful while using it for irrigation of the agricultural fields. Besides, the discharge criteria applied to industrial and urban wastewater treatment plants must be rearranged and should be closely monitored by the local authorities.

ACKNOWLEDGEMENTS

This manuscript was prepared from the MSc. thesis. The authors thank to Mr. Sita Sanele KUNENE for his critical check on the English grammar of the manuscript.

REFERENCES

Aksoy, E. ve G. Özsoy. 2002. Investigation of multi-temporal land use/cover and shoreline changes of the Uluabat lake Ramsar site using RS and GIS. In Proceedings of the International Conference on Sustainable Land Use and Management, 10-13 June 2002, Çanakkale, Turkey, 318-325.

Anonymous 2007. Bursa su ve kanalizasyon idaresi (Buski), çevre raporu, Bursa.

Ashraf, M.A., M.J. Maah and I. Yusoff 2010. Water quality characterization of varsity lake, University of Malaya, Kuala Lumpur, Malaysia. Journal of Chemistry, 7(1), 245-254.

Bauder, T.A., R.M. Waskom, P.L. Sutherland and J.G. Davis. 2014. Irrigation water quality criteria. Colorado State University Extension. Fact Sheet No. 0.506.

Bouman, B. A. M. and T. P. Tuong 2001. Field water management to save water and increase its productivity in irrigated lowland rice. Agricultural Water Management, 49(1), 11-30.

Bouwer, H. 2000. Integrated water management: emerging issues and challenges. Agricultural Water Management, 45(3), 217-228.

Breś, W., T. Kleiber, and T. Trelka. 2010. Quality of water used for drip irrigation and fertigation of horticultural plants. Folia Horticulturae 22(2), 67-74.

Deng, X. P., L. Shan, H. Zhang and N. C. Turner. 2006. Improving agricultural water use efficiency in arid and semiarid areas of china. Agricultural Water Management, 80(1), 23-40.

Devirian, T.A. and S.L. Volpe. 2003. The physiological effects of dietary boron. Critical Reviews in Food Science and Nutrition, 43:2, 219-231.

Fipps, G. 2003. Irrigation water quality standards and salinity management strategies. Texas Farmer Collection. Http : / /Hdl .Handle .Net /1969 .1 /87829.

Güleryüz, G., H. Arslan, C. Çelik, Ş. Güçer and M. Kendall. 2008. Heavy metal content of plant species along Nilüfer stream in industrialized Bursa city, Turkey. Water, Air, and Soil Pollution, 195(1-4), 275-284.

Hopkins, B.G., D.A. Horneck, R.G. Stevens, J.W. Ellsworth and D.M. Sullivan. 2007. Managing irrigation water quality for crop production in the Pacific Northwest. [Covallis, Or.]: Oregon State University Extension Service.

Horneck, D.A., J.W. Ellsworth, B.G.Hopkins, D.M. Sullivan and R.G. Stevens. 2007. Managing salt-affected soils for crop production. [Covallis, Or.]: Oregon State University Extension Service.

Jones, J.R. and J. Benton. 2001. Laboratory guide for conducting soil tests and plant analysis. Crc Press, p. 384.

Karaer, F. and A. Küçükballi. 2006. Monitoring of water quality and assessment of organic pollution load in the Nilüfer stream, Turkey. Environmental Monitoring and Assessment, 114 (1-3), 391-417.

Kocaer, F.O. and H.S. Başkaya. 2004. Some chemical properties of soils non irrigated and irrigated with Nilüfer-Ayvali stream in Bursa. Ekoloji, 13(51), 33-38.

Mussa, S.B., H.S. Elferjani, F.A. Haroun and F.F. Abdelnabi. 2009. Determination of available nitrate, phosphate and sulphate in soil samples. International Journal of Pharmtech Research, 1(3), 598-604.

Özbek, H. 1990. Toprak bilgisi, Ç.Ü. Ziraat Fak. Ofset ve Teksir Atölyesi, Adana. (in Turkish)

Öztürk, B.Y. and C. Akköz 2014. Investigation of water quality of Apa dam lake (Çumra-Konya) and according to the evaluation of pca. Biodicon, 7(2), 136-147.

Parsons, T. R. A. 2013. Manual of chemical & biological methods for seawater analysis. Elsevier. p.188.

Sellamuthu, K. M., C. Mayilswami, A. Valliammai, and S. Chellamuthu. 2011. Effect of textile and dye industrial pollution on irrigation water quality of Noyyal River Basin of Tamil Nadu. Madras Agric J. 98(4-6): 129-135.

Svobodá, Z., R. Lloyd, J. Máchová and B. Vykusová. 1993. Water quality and fish health, FAO, Eifac Technical Paper, No: 54.

Şener, Ş. and D. Güneş. 2015. Aksu (Isparta) ovası yüzey ve yeraltı sularının hidrojeokimyasal özellikleri ve su kalitesi. Pamukkale Univ Muh Bilim Derg, 21(6), 260-269.

Tepe, Y. and C.E. Boyd. 2003. A reassessment of nitrogen fertilization for sunfish ponds. Journal of World Aquaculture Society, 34 (4): 505-511.

Uslu, O. and A. Turkman. 1987. Su kirliliği ve kontrolü. T.C. Başbakanlık Çevre Genel Müdürlüğü Yayınları. No:1 Ankara.

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

Üstün, G.E. 2011. The assessment of heavy metal contamination in the waters of the Nilüfer stream in Bursa. Ekoloji, 81, 61-66.

Üstün, G.E., F. Karaer and S.K.A. Solmaz. 2008. Bursa Nilüfer çayının sulama suyu olarak kullanılabilirliğinin değerlendirilmesi, In Proceedings of Su Tüketim, Arıtma, Yeniden Kullanım Sempozyumu, 3-5 Eylül 2008, 97-104.

Yalılı, M. and S.K.A. Solmaz. 2004. Su temini tesislerinin tarihsel gelişimi sürecinde Bursa ili. Uludağ Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi, 9 (1):171-181.