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Research Article

Faraz Stream (Hafik-Sivas) Water Quality Characteristics and Monthly Variations

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Abstract

In this study, it is aimed that to determine some water quality properties of Faraz Stream which passes through the forestland of Kızılcadağ located within Sivas Province boundaries and joins into Tozanlı stream located within the boundaries of Sivas Province Hafik District, supplying 4-5 villages water requirements around. Water quality parameters, dissolved oxygen (DO), salinity, pH, temperature and electrical conductivity (E.İ) was measured directly in the field with the help of devices. Other water parameters as suspended solids (TSS), chemical oxygen demand (COD), total alkalinity, total hardness, total ammonium nitrogen, nitrite, nitrate, ammonia, phosphate, sulfate, sulfite, free chlorine, sodium, magnesium, calcium, iron, lead, copper and cadmium are analyzed on the same day by bringing the water samples to the lab. In this performing study for Faraz Stream, which is one of the most important streams consisting of the Tozanlı Stream, water quality of the stream is followed by physico-chemical methods during a year, variation of water quality data recorded month by month, evaluated and discussed in terms of aquaculture and aimed to the creation of the data source which will be held in the future for research.

Keywords: Water Pollution, Faraz Stream, Hafik, Sivas

INTRODUCTION

Due to industrialization and urbanization duration of those days, water usage and consumption rates increase and the requirements of sustainable clean water resources arise day by day. On the other hand, rivers are being polluted physically, chemically and biologically as a result of irregular and wrong usages, just like standing waters. The pressures on natural environment, ecosystems and ecological species are getting heavier and self-cleaning and self-replenishment abilities of subsurface and surface waters, especially those of rivers, are being irreversibly rusted (Bulut and Tüfekçi, 2010). Because rivers having important role in water cycle are always under pressure of human activities, the quality of water decreases gradually with the effects of domestic, industrial and agricultural polluters (Soylak and Doğan, 2000). The amount of usable water per capita in our country is 1735 m^3. Considering that the average of Europe is 5000 m^3, it can be seen that our country is one of the countries having scarcity in terms of existence of usable water per capita (Bektaş et al., 2011). Besides increasing water requirement, fresh water sources', which have great importance nowadays, being under pollution threat led studies about water pollution to increase. In order to determine the pollution in rivers, physical, chemical and biological factors are used. If the factors affecting water quality are not monitored with certain time intervals, and if the required measurements are not taken, some situations hard to compensate may arise and creatures living in water may face with threat of extinction. That's why; existence of quality water is very important. Brook Faraz, where the study was conducted, arises from south slopes of Mount Kızılca, which is one of the south extensions of North Anatolian Mountain Chains. Passing through sheer slopes and forests, Brook Faraz conjoins with

Brook Tozanlı within the borders of Akkaya Village of Hafik district. Total length of Brook Faraz is 22 km, and its mean annual flow rate is 55 m^3/h. Mostly the Black Sea climate is seen in region which is a passage area between Black Sea and Central Anatolia. In region; winters are warm and summers are cool and light-rainy.While the mean annual precipitation is 464.4 mm, the highest point is May with 58.7 mm and the lowest point is August with 9.5 mm. While the mean temperature is 13.7˚C, the coldest month is January with 2.6˚C and the hottest month is July with 22.3˚C. The mean annual relative humidity rate in region is 71% (Anonymous, 2013). Brook Faraz has great importance because of its location. It contributes on economy of region by being used in watering of agriculture fields and fruit orchards, also by satisfying drinking water needs of 5 villages being within the borders of Hafik district in Tozanlı valley.

The aim of this study is to observe the water quality specifications and monthly changes of Brook Faraz, which arises from Mount Kızıl and passes through sheep valleys and forests and conjoin with River Tozanlı within the borders of Akkaya village of Hafik district of Sivas city, and which satisfies drinking water needs of 5 villages, with physical and chemical methods and to determine and record the annual and monthly changes of water quality.

MATERIAL AND METHOD

Brook Faraz being within the borders of Tozanlı Valley of Hafik district of Sivas city is famous with being a high flow rate brook passing through sheep slopes and forests, and with being one of the most important water resources of River Tozanlı. Gürpınar Vilage, which is 70 km away from Sivas city center and 75 km away from Hafik district is one of the villages with highest population in Tozanlı Valley, there are some records in Ottoman archives about this village from year of 1454. There are 2 table lands named Faraz and Meydan. Faraz tableland which belongs to Gürpınar Village is being used as settlement and picnic field. The source of Brook Faraz is Mount Kızılca. The only station determined in this study is the front of visitation point in exit of Gürpınar Village.

Figure 1. The Location of Sivas City and Lake Faraz

Temperature values of Brook Faraz vary significantly. While annual average temperature is 11.58˚C, the lowest value belongs to February of 2012 (6.3˚C) and the highest value belongs to September of 2012 (16.8˚C). Also the seasonal average temperatures are as follows; Winter 7.8˚C, Spring 9.37˚C, Summer 14.47˚C and Autumn 14.70˚C (figure 2).

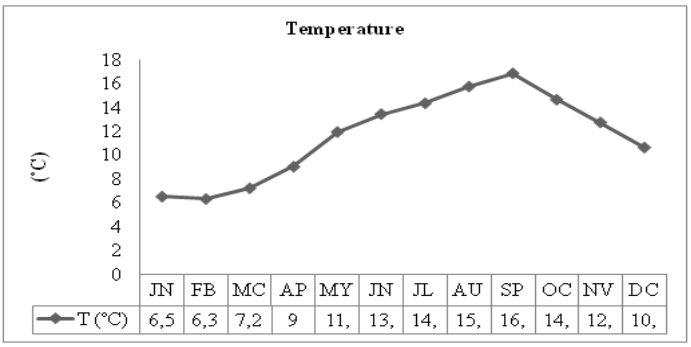


Figure 2. Monthly Temperature (˚C) Values

The pH value showing the acidic or basic situation of waters showed that water of Brook Faraz is relatively basic. The lowest pH value was recorded in February as 7.48, and the highest value was recorded in September as 8.08. It was understood that there are seasonal differences between pH values. While pH values decreased in winter months, they increased in summer season. The mean pH values of Brook Faraz are as follows; Winter - 7.53, Spring - 7.81, Summer - 8.00 and Autumn - 7.84 (Figure 3).

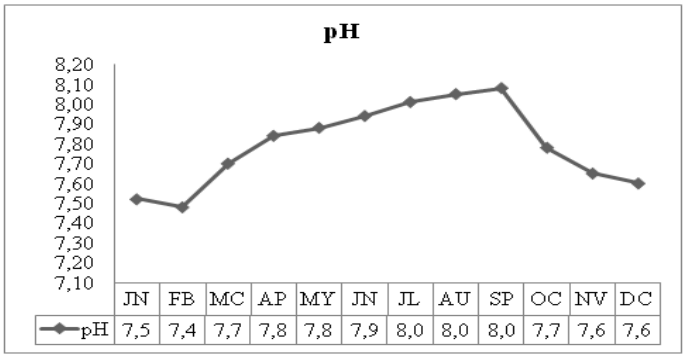


Figure 3. Monthly pH Values

During the year, the Amount of Dissolved Oxygen in Brook varied from month to month and from season to season. Mean annual dissolved oxygen amount was 11.79 mg/L, the lowest point was in September 2012 (7.82 mg/L) and the highest point was in February 2012 (14.09 mg/L). The seasonal dissolved oxygen amount averages of brook were as follows; Winter - 13.79 mg/L, Spring - 13.01 mg/L, Summer - 9.80 mg/L and Autumn - 7.82 mg/L (Figure 4).

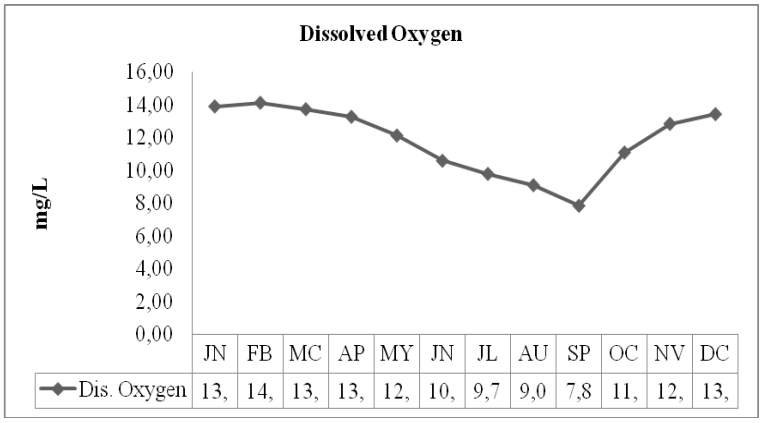


Figure 4. Monthly Dissolved Oxygen Amounts (mg/L)

Salinity in Brook Faraz showed differences between seasons. It decreases in winter months, ad it increased in summer months when evaporation increased. The lowest values were measured in January and February of 2012 as 0.1 ppt, while the highest values were measured in September of 2012 as 0.12 ppt. Mean salinity was calculated as 0.06 ppt.

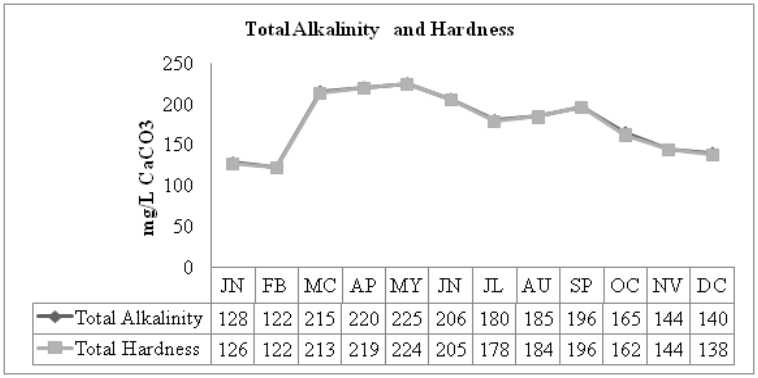
The salinity values were determined for winter, spring, summer and autumn as 0.01 ppt, 0.05 ppt, 0.10 ppt and 0.09 ppt, respectively.

Electrical Conductivity (EC) values showed significant differences seasonally in region. In parallel with salinity values, Electrical Conductivity (EC) values decreased in winter months, and then they increased in summer, when evaporation increased. Mean EC was calculated as 163.75 ns/cm. Minimum EC was calculated as 102 ns/cm in February, and maximum EC was calculated as 226 ns/cm in September.

Suspended Solid Matter (SSM) amounts of Brook Faraz varied monthly and seasonally. While mean SSM value was found as 0.86 mg/L, the lowest value was found as 0.03 mg/L for February 2012 and the highest value was found as 1.83 mg/L for September 2012. The seasonal SSM averages of brook were found as follows; Winter 0.09 mg/L, Spring 0.43 mg/L, Summer 1.63 mg/L and Autumn 1.30 mg/L.

Total Alkalinity values of brook showed significant variations seasonally and monthly. While total alkalinity values of brook decreased in winter, the lowest value was measured February 2012 as 122 mg/L $CaCO_3$. While total alkalinity values increased in spring season, the highest value was found in May 2012 as 225 mg/L $CaCO_3$. The seasonal averages of alkalinity values were as follows; Winter - 130 mg/L $CaCO_3$, Spring - 220 mg/L $CaCO_3$, Summer - 190.33mg/L $CaCO_3$ and Autumn - 168.33 mg/L $CaCO_3$.

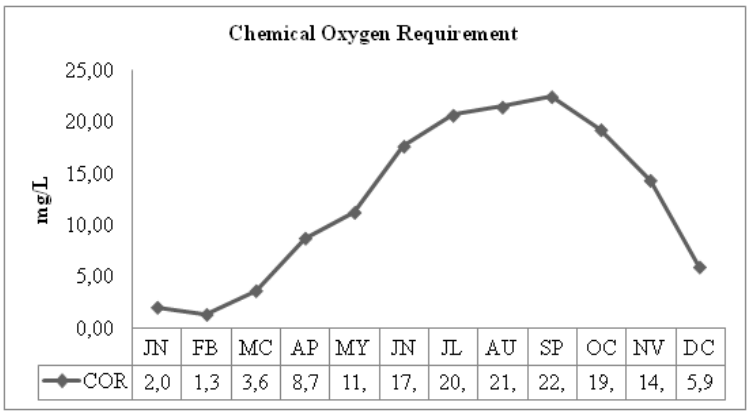
The total hardness value averages of Brook Faraz were determined as follows; Winter - 128.67 mg/L $CaCO_3$, Spring - 218.67 mg/L $CaCO_3$, Summer - 189 mg/L CaCO3 and Autumn - 168.33 mg/L $CaCO_3$. The lowest total hardness value was determined as 122 mg/L $CaCO_3$ for February 2012 and the highest total hardness value was determined as 205 mg/L $CaCO_3$ for June 2012. Annual mean hardness value was calculated as 175.91 mg/L $CaCO_3$ (Figure 5).



	JN	FB	MC	AP	MY	JN	JL	AU	SP	OC	NV	DC
Total Alkalinity	128	122	215	220	225	206	180	185	196	165	144	140
Total Hardness	126	122	213	219	224	205	178	184	196	162	144	138

Figure 5. Monthly Total Alkalinity and Total Hardness Values (mg/L $CaCO_3$)

The average of Chemical Oxygen Requirement (COR) of brook was found as 12.35 mg/L. Minimum value was found as 1.30 mg/L in February 2012 and maximum value was found as 22.40 mg/L in September 2012. The mean values were as follows; Winter 3.07 mg/L, Spring 7.83 mg/L, Summer 19.87 mg/L and Autumn18.63 mg/L (Figure 6).



	JN	FB	MC	AP	MY	JN	JL	AU	SP	OC	NV	DC
COR	2,0	1,3	3,6	8,7	11,	17,	20,	21,	22,	19,	14,	5,9

Figure 6. Monthly Chemical Oxygen Requirement (COR) Values mg/L

The nitrite level of Brook Faraz was close to zero level. No significant difference was observed for levels of nitrite during the year. Like nitrite levels were found as being close to zero. Slight increases were observed in levels of nitrite in summer and autumn months. While differences were observed in nitrate levels monthly during the year, it could not be

determined in December, January and February. But it reached at maximum value in July 2012 with 3.1 mg/L. Mean values of nitrate were measured as follows seasonally; Winter 0.00 mg/L, Spring 1.36 mg/L, Summer 2.23 mg/L and Autumn - 1.60 mg/L. The ammonium nitrogen (NH4) level of brook was in parallel with that. While it could not be determined in winter months, it could be determined as averagely 0.01 mg/L in summer months (Table 1).

While chloride values showed variation during the study, the annual average was found as 13.92 mg/L. Minimum point was found for September 2012 as 5.77 mg/L, while maximum point was found for January 2012 as 25.02 mg/L. The seasonal averages were determined as follows; Winter - 22.68 mg/L, Spring 16.37 mg/L, Summer 6.64 mg/L and Autumn 10.01 mg/L.

The magnesium and calcium values of Brook Faraz showed changes similarly. Mean magnesium and calcium values of brook showed monthly and seasonal changes. While Mg and Ca values of brook decreased in winter months, the lowest Mg value was measured in January 2012 as 6.7 mg/L and the lowest Ca value was measured in February as 6.2 mg/L. While Mg and Ca values increased in spring season, the highest Mg and Ca values were measured in May 2012 as 17.4 mg/L and 3.67 mg/L, respectively (Table 1).

The phosphate level of Brook Faraz was found as being close to zero. While slight differences were observed in phosphate levels during the year, no phosphate could be determined in winter months. It showed slight increases in summer months. Annual mean phosphate value was found as 0.05 mg/L. While maximum level of phosphate was found as 0.14 mg/L in September 2012, the averages for spring and summer and autumn were as follows; 0.02 mg/L, 0.11 mg/L and 0.07 mg/L, respectively.

The sulfate value of brook showed significant monthly and seasonal changes. The minimum point was observed in February 2012 as 5.3 mg/L, while the maximum point was observed in September 2012 as 61.8 mg/L. Seasonal averages were determined as follows; Winter 10.04, Spring 10.73, Summer 45.27 and Autumn 34.8 mg/L.

Seasonal averages of sulfite values of Brook Faraz were determined as follows; Winter 0.40 mg/L, Spring 1.83 mg/L, Summer - 4.80 mg/L and Autumn 3.97 mg/L. the lowest sulfite value was determined for February 2012 as 0.1 mg/L, while the highest one was found for September 2012 as 5.8 mg/L. Mean annual sulfite value was 2.75 mg/L (Table 1).

Mean annual potassium value of brook was measured as 2.92 mg/L. The highest value was measured in May 2012 as 4.9 mg/L, while the lowest value was measured in January as 1 mg/L. mean seasonal values were found as follows; Winter 2.17 mg/L, Spring (highest) 4.23 mg/L, Summer 2.47 mg/L and Autumn 2.83 mg/L. The mean annual sodium amount was found as 25.52 mg/L, while the lowest amount was found in September 2012 as 5.3 mg/L and the highest amount was found in May 2012 as 52.8 mg/L. The seasonal averages of sodium were determined as follows; Winter 28.3 mg/L, Spring 46.8 mg/L, Summer 15.53 mg/L and Autumn 11.47 mg/L (Table 1).

Copper and lead levels in Brook Faraz have been in very low degrees during the year. They have never exceeded the acceptable level in any month. While the irons levels varied monthly, its lowest level was in September 2012 as 0.001 mg/L and its highest level was in June 2012 as 0.016 mg/L. The levels of lead have stayed in very low degrees during the year, and it was found as 0.011 mg/L in September 2012 (exceeding the acceptable level). While no lead was detected in brook, the lead level slightly increased through summer months.

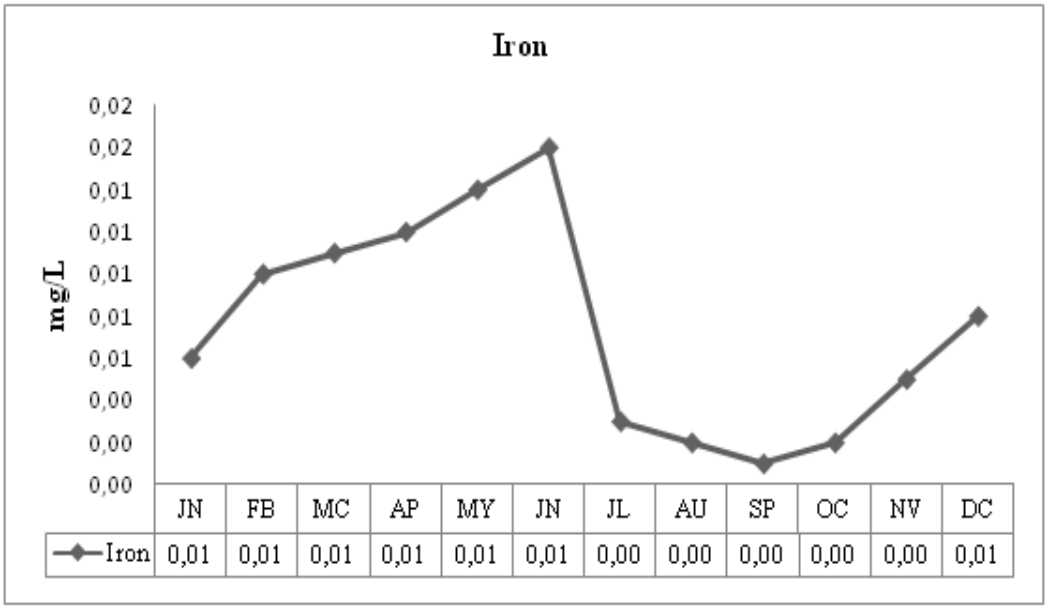


Figure 7. Monthly Iron Values mg/L

Table 1. Seasonal Values and Standard Deviation of Averages of Water Quality Parameters of Brook Fara

ARAMETERS/SEASONS	WINTER	SPRING	SUMMER	AUTUMN	SD
DISSOLVED OXYGEN (mg/L)	13,79	13,01	9,80	10,56	1,91
SALINITY(%)	0,01	0,05	0,10	0,09	0,04
PH	7,53	7,81	8,00	7,84	0,20
ELECTRICAL CONDUCTIVITY	109,67	152,33	203,67	189,33	42,04
SUSPENDED SOLID MATTER (mg/L)	0,09	0,43	1,63	1,30	0,72
CHEMICAL OXYGEN REQUIREMENT (mg/L)	3,07	7,83	19,87	18,63	8,22
NITRITE (NO_2)(mg/L)	0,005	0,012	0,020	0,021	0,01
CHLORIDE (Cl) (mg/L)	22,68	16,37	6,64	10,01	7,10
FOSFAT (PO_4) (mg/L)	0,00	0,02	0,11	0,07	0,05
SULFATE (SO_4) (mg/L)	10,04	10,73	45,27	34,80	17,65
SODIUM (Na) (mg/L)	28,30	46,80	15,53	11,47	15,89
POTASSIUM (K) (mg/L)	2,17	4,23	2,47	2,83	0,91
TOTAL HARDNESS (mg/ L CaCO3)	128,67	218,67	189,00	167,33	37,88
TOTAL ALKALİNİTY (mg/L CaCO3)	130,00	220,00	190,33	168,33	37,91
Mg (mg/L)	6,67	16,37	11,30	9,03	4,14
Ca (mg/L)	6,70	30,57	14,13	10,23	10,55
Fe (mg/L)	0,01	0,01	0,01	0,00	0,00
AMMONİUM NİTROGEN(mg/L)	0,000	0,000	0,010	0,010	0,006
NITRATE (NO_3) (mg/L)	0,00	2,50	2,23	1,60	1,12
SULFITE (mg/L)	0,40	1,83	4,80	3,97	2,00
LEAD (mg/L)	0,00	0,00	0,01	0,01	0,01
COPPER (mg/L)	0,00	0,00	0,01	0,01	0,01
CADMİUM (mg/L)	0,00	0,00	0,01	0,01	0,01
TEMPERATURE (C)	7,80	9,37	14,47	14,70	3,52

DISCUSSION

The measurements of temperature which decreased during the year showed significant differences between months. Temperature is one of the most important parameters being effective on aquatic environment. It is known that temperature varies in aquatic environments due to climate, altitude, atmosphere conditions and flow speed (Bektaş et al., 2011). While water temperature is very important in lives of fishes, fishes are classified into 3 classes as cold water fishes, warm water fishes, and mild water fishes (Aras et al., 1995).

In terms of water temperature, it is reported that the optimal conditions for salmon breeding is 7-18 ˚C, that for carp breeding is 16-26 ˚C (Verep et al., 2005). During our study, temperature changes in stations were within the normal limits according to seasonal conditions. Temperature differences observed during the year did not exceed the level where fishes living in brook are disturbed. The maximum temperature value of Brook Faraz was measured in September 2012 as 16.8 ˚C.

The pH value showing the balance between acid and base in water is one of the basic parameters which should be measured in all water chemistry and pollution studies. Besides playing role in some chemical reactions in living organisms, acidic waters increase the toxic effects of some chemicals and metals when they interact (Bektaş et al., 2011). An aquatic environment's pH value's being available for using in fish breeding, it should be between 6.5 and 8.5 where it won't harm living environment of any creature (Kara and Colekcioglu, 2004). Although monthly pH changes of Brook Faraz were not high, they were slightly basic. The pH values increasing in summer decreased in winter months. It can be said that the pH of Brook Faraz is suitable for water creatures and fishes.

It is the fact that dissolved oxygen arranges and limits the lives of creatures in aquatic environments. During the study, dissolved oxygen amount was found high in winter months, and it decreased slightly in summer months. In terms of dissolved oxygen amount, water of Brook Faraz is prime quality according to Water Pollution and Control Legislation and Drinking Water Standards (Anonymous, 2010).

The nitrogen resources mixing into surface waters are basically natural-, domestic-, industrial- and agricultural-originated. Nitrogen derivatives such as, nitrate, nitrite and ammonium-nitrogen amounts varied monthly during the year. While no nitrite could be determined in winter months, it increased slightly in summer months. While nitrite can rarely reach at high concentration levels in surface waters, it can easily transform into nitrate in surface waters. Ammoniac is the basic nitrogenous waste output comprising of animal wastes. Also, ammoniac arises as a result of decomposition of nitrogenous organic matters. The ammoniac accumulation in water is not desired because it is toxic for aquatic organisms. Its toxic effect increases while pH and temperature increase (Tepe, 2009). The nitrate in natural waters is common form of inorganic complex nitrogen; it is the final output of nitrification in unpolluted surface waters. While no

nitrate could be found in brook during winter months, nitrate value increased in summer months and was determined as highest in July (3.1 mg/L). In terms of nitrate amount, water of Brook Faraz is prime quality according to Water Pollution and Control Legislation and Drinking Water Standards (Anonymous, 2010). Ammonium-nitrogen (NH4) is required to exist less than 1 mg/L in normal waters. While no ammonium-nitrogen (NH4) was found in winter months, it reached at its highest level in September 2012 as 0.02 mg/L. This level is 1/50 of acceptable level.

Total alkalinity of water is the index of total concentrations of titra table bases. According to Water Pollution and Control Legislation and Drinking Water Standards (Anonymous, 2010), the waters containing alkalinity value between 20 and 300 mg/L CaCO3 are normal waters. While total alkalinity and hardness values in Brook Faraz have progressed parallelly during the year, total alkalinity values were 1-2 mg/L more than total hardness values. In waters on calcareous soils, total alkalinity and total hardness values are generally close or equal to each other (Mutlu and Yanık, 2012). The total alkalinity and total hardness values in brook are in conformity with water quality criteria, it was determined that they are within the optimum limits for aquatic creatures and fish-breeding.

COR being used with strong chemical oxidants in decomposition of natural and pollutant loads reached at its highest level in September 2012 as 22 .40 mg/L and its lowest level in February 2012 as 1.30 mg/L. The reason of COR's increase from April 2012 to September 2012 is the possibility of domestic wastes, animal wastes and fertilizers mixing from lands and villages around to brook.

The phosphor being a key product exists in unpolluted natural waters between 0.01 and 0.03 mg/L, and it determines the productivity of aquatic organisms in fresh water resources, such as plankton (Tepe and Boyd, 2003). The reason of increase of phosphate in summer months may be originated from increase of blue-green algae, usage of phosphorous fertilizers, and the leakage of phosphor from rooted aquatic plants to water (Tepe, 2009).

The Electrical Conductivity (EC) being a parameter of ionic capacity of water varies due to dissolved inorganic matter concentration and salinity in water. Electrical conductivity is very important for aquacultures; conductivity exceeds the value of µmhos/cm when pollution increases (Verep et al., 2005). The EC in Brook Faraz showed parallelism; it showed increase in summer months while it was low in winter months. The highest EC value was observed in September as 226.00 µmhos/cm, it is very low. It was determined that the brook is in very good conditions in terms of EC and salinity.

Chloride, one of the mineral salts dissolved in water, has effects on distribution of living creatures in all natural waters. While chloride may be domestic-, agricultural- and industrial-originated, it may also be mineral-originated (Cicek and Ertan, 2012). While chloride levels varied monthly and seasonally in study, the highest value was observed in January 2012 as 25.02 mg/L and the lowest value was observed in September 2012 as 5.77 mg/L. In terms of chloride amount, water of Brook Faraz is prime quality according to Water Pollution and Control Legislation and Drinking Water Standards (Anonymous, 2010). Chloride may exist in natural waters in amount of 30 mg/L (Yaramaz, 1992).

Ca^{++} and Mg^{++} are two of the most important dissolved solid matters in water. While Ca is the ion with the highest amount in environment, it interacts with metabolic activities of all living creatures. It is reported that there is a relationship between Ca^{++} existence and the existence of some invertebrate organisms in aquatic environments, and that it has effects on shells of some aquatic creatures, lime accumulation in vertebrates and plants, creation of bones, development of algae and high plants, and distribution of other creatures (Tanyolac, 2000).

The existence of Ca wit amount of 5-60 mg/L in normal water is normal. While its existence with amount of 80-100 mg/L in relatively hard waters can be evaluated as acceptable, the highest recommendable value for Ca^{++} is 75 mg/L. During the study, it was seen that Ca++ value has progressed within normal limits in months.

Mg++ has vital importance for plants with chlorophyll in waters. It regulates the phosphor metabolism in algae, fungi and bacteria. The adequate existence of Mg in fresh waters is very important for this reason. It was reported that it should exist in normal waters in amount of 50-150 mg/L (Cicek and Ertan, 2012). In our study, the amounts of Mg were determined within the recommended limits during the year.

Sulfate affects the plant development, biological productivity, and protein metabolism in natural waters; sulfate deficiency prevents the development of algae and slows down the growth of plants. While sulfate (SO_4^{-2}) is decreased into sulfur elements in anaerobic environments, it is used in chemosynthetic situations by sulfur-bacteria. It is reported that various industrial wastes, agricultural activities and domestic wastes increase the sulfate concentration in fresh waters (Cicek and Ertan, 2012). The sulfate value in natural waters varies between 5 and 100 mg/L, but the level of maximum sulfate existence for aquaculture was determined as 90 mg/L (Küçük, 2007). The sulfate value was significantly lower than acceptable value during the study year, so the water is very suitable for aquacultures.

The sulfite value measured in study was Na_2SO_3 (Sodium sulfite). The sulfur in organic matters generally exists in proteins; sulfur is oxidized into sulfate under aerobic conditions, and it doesn't transform into harmful form (hydrogen sulfite (H_2S)) (Tepe et al., 2006). During the study, sulfite has not exceeded the dangerous limit.

Potassium varies between 1 and 10 mg/L in natural waters (Boyd, 1998). During this study, the mean annual potassium value was calculated as 2.92 mg/L. But sodium salt varies between 2 and 100 mg/L in natural waters. The sodium average was calculates as 25.52 mg/L in this study. The levels of potassium and sodium has increased in spring

season and decreased in summer season. Potassium and sodium salts did not exceed the pollutant level during this study.

The values of copper and lead and cadmium which were examined in study have progressed similarly. While elements were not determined in water during winter months, they never exceeded the acceptable level although they slightly increased in summer months. By finding the level of ferrous in water as 0.016 mg/L in spring months and especially in June 2012, it was reported that it exceeded the acceptable level. It is thought that the reason is that wheat breeding activities are performed in farms around brook, and that the agricultural pesticides used frequently in order to make wheat to be fruitful contain ferrous.

During the physical and chemical water analyses conducted in Brook Faraz which has quality water and where there is no significant problem in terms of water pollution and quality, it was reported that the ferrous element exceeded slightly the acceptable levels in months when pesticides were implemented for fruitfulness. It was revealed that the COR levels got closer to dangerous levels in September when the dissolved amount was minimum and the population in lands and villages around brook were maximum because organic-pollution creator organic fertilizers, animal wastes and domestic wastes might mix in brook. There is no industrial company around Brook Faraz, but there are agricultural fields where dense agricultural activities are conducted. It was revealed that the both domestic- and agricultural-originated wastes are not in adequate quantity and qualification in order to impair the quality of brook's water. The protection of water quality of Brook Faraz, where it is known that many fish species still live, is an inevitable necessity for sustainability of natural ecological balance comprising of natural fish stocks and other aquacultures, and for providing the drinking water requirements of villages in Tozanlı Valley.

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