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THE DAM EFFECTS ON THE DISTRIBUTIONS OF FISH ASSEMBLAGES AND WATER QUALITY ON THE RIVER YESILIRMAK (TURKEY) USING PRINCIPLE COMPONENT ANALYSIS

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ABSTRACT

There are multiple effects of human induced like dams on river ecosystems. Transforming the river into a lake, dams interrupt the continuity of river flow to downstream, affecting the water quality as well as biodiversity and behavior of the species in the river stretch below the dam. There can be an environmental filter through which only the species exhibiting strategies adapted to the new environment. In order to pass through environmental filter fish must be adapted to, or they must be able to change their behavior according to hydrological changes in the new environment. Otherwise, they have to migrate to an appropriate medium if they find on the river. A similar situation arises when two different dams (Suat Ugurlu and Hasan Ugurlu Dam Reservoirs) are built on the river in Yeşilırmak river basin.

The aim of this study was to determine hydrological effects on fish population and the water quality of the River Yeşilırmak (Turkey). In the study, an assessment of water quality varieties between lotic and lentic habitats on Yeşilırmak River (Turkey) is presented. Seasonal samples were taken from April 2008 to July 2009 at 9 sampling sites of riverine and dam lakes built on the river. According to the results of analysis of some water quality parameters; water depth, turbidity, current speed, chlorophyll-a and nutrients of water significantly varied between dam and river sections of Yeşilırmak. Existence of dams have clearly formed spatial differences between river and lakes in terms of fish species. On the other hand, water quality data indicated that river and dam lake water had water quality classes ranging from 1 to 3. It seemed that intensive agricultural, industrial and anthropogenic activities could be responsible for creating this variability in water class level.

KEYWORDS:
Water Quality, Habitat Change, Dam, River, PCA

INTRODUCTION

Developing countries that are not rich in fossil energy resources, such as natural gas and oil are on the verge of maximizing the use of their hydroelectric water capacity. This causes changes in ecological structure of many rivers which in turn causes many species to be destroyed or threatened. Although the energy generated by hydropower power plants is within clean and recyclable energy category, ecological problems can arise if the rivers are turned into the lakes [1, 2].

Dams have positive and negative impacts on the environment as well as benefits such as controlling river regimes, preventing floods, obtaining domestic and irrigation water from stored water and generating energy. The ecological effects of dams can be classified according to different criteria such as long-term and short-term effects, impacts on surrounding regions, and areas where dam services, social and non-social effects, beneficial and harmful effects. These effects may be ordered in an intensive and complicated manner like climatic, hydraulic, biologic, social, cultural, archaeological etc. [3, 4, 5, 6].

For example; This is an important intervention in nature if the precautions of the streams that provide the sustainability of the existing ecosystem in the basin are prevented by human influence. In particular, dams built in front of large rivers containing high energy are highly likely to have different effects on the rivers above the dam. Above the dam, the stream environment is about to change the lake, while below the dam there is a stream environment with a changed flow regime. Physicochemical water quality such as depth, water temperature, flow, nutrients change in the pre-dam lake environment and the ecosystem changes into lake ecosystem over time. It is a known fact that the climate of the region changes, primarily the increase in moisture content and precipitation after the construction of the dams.

Excessive conditions such as drought or unexpected flooding can occur with an undesirable decrease in the amount of water as the river regimes

change with the construction of dams. In these cases, besides the vegetation on the riverside, living things and sensitive organisms in the river are adversely affected. After discharge, some toxic substances (pesticides, heavy metals and organic pollutants, etc.) may reach a level that can threaten aquatic life [7].

Hydrological modifications can adversely affect the ecological structure and water quality of river systems. In a study of Manwan and Dachaoshan Dam from Lancang River in China, the dam construction and operation has various impacts on water quality and water self-purification capacity as from pre-dam period to dam working period, the dam affected reservoir water quality negatively in dry season and did little in flood season and then to the next 5 years after the closure of the dam, the dam affected reservoir water quality positively in both dry season and flood season [8]. Some significant disadvantages can occur in the river basin, such as interruptions and changes in the downstream flow of the water through the dam construction, formation of reduced areas of water cover in the river bed, changes in species number and distribution in riverine types and other organisms in terms of aquatic life, suspension and sedimentation. It even brings water-borne diseases (typhus, typhoid fever, malaria and cholera) due to the swampy areas that occur to humans, and it can narrow down residential areas such as cities and rural areas [9].

Dams expand the water area by stopping the river flow, accumulating water, increasing depths, reducing flow rates considerably and reducing the spread and dilution of pollutants. Thus, the risk of eutrophication will increase as the concentrations of nutrients such as nitrogen, phosphorus and potassium in reservoir waters. On the other hand, the amount of pollutants will increase with time, decreasing the dispersions and dilutions because more toxic discharge for the creatures' decreases. Therefore, with the establishment of reservoirs on the rivers of dams, economic and social benefits as well as many ecological problems, hydrological changes and water quality deterioration will occur [10, 11].

The dams that set the natural flow of the rivers can not only change the hydrology of the rivers but also the physical, chemical and biological properties of the rivers by converting the moving river waters into still lake waters [12]. Biological surveys such as water temperatures, fish migrations and changing flow regimes, which are ecological effects of dams are critically important. However, more frequent geomorphological changes are the key to understanding the long-term ecological consequences of dams and the deterioration of rivers [13]. At the same time, dams and reservoirs have effects and hazards on hydrological system and river dynamics, physico-chemical cycles, soil, surface and groundwater quality and environmental toxicity and ecosystems [14].

The effects of dams are not only on the river ecosystem but also on their impact on the marine ecosystem. The construction of dams on naturally flowing rivers tends to decrease discharge of surplus water into the sea. The reducing nutrient concentration in estuaries and coastal waters diminishes plankton blooms as well as fish landings. On the other hand, depletion of nutrients and organic matter along with reduced mud and silt deposition affects benthic life on the continental shelf and so reduced mud and silt deposition lead to coastal retreat [15]. Humborg et al. (1997) reported in a study that the construction of dams on the Danube River indicates that significant changes are observed in the surface waters of the Black Sea [16]. The reduction of dissolved nitrogen and silica, which is carried by the Danube due to dams, indicates that the phytoplankton composition of the Black Sea has changed from diatoms to coccolithophore and dinoflagellates. For this purpose, in this study, the effects of Suat Ugurlu and Hasan Ugurlu dams on the river ecosystem will be evaluated using Principal Component Analysis in terms of physico-chemical water quality parameter changes and fish species composition and densities in river areas around dam reservoirs.

MATERIALS AND METHODS

Study area. This study was carried out in the lower basin of the River Yesilırmak in Turkey. The river originates within the Kose Mountain located on the northeastern parts of Turkey and flowing into the Black Sea near Çarsamba, a district of Samsun. The river, which is the second longest river (529 km) of Turkey, contains three main branches Kelkıt, Çekerek and Tozanlı. The natural flow of the river is interrupted by five main power plants which were built on the River Kelkit (Kılıçkaya Power Plant), on the River Tozanlı (Almus and Ataköy) and on the main channel (Hasan Ugurlu and Suat Ugurlu).

This study was performed on the lower portion of the river basin at consecutive nine stations. Three sites (1,2,3) (BÇ) were located on the downstream just below Suat Ugurlu Dam Lake, which was constructed in 1981 for production of electricity; four of them were placed within the Suat Ugurlu (4,5) (SUBG) and Hasan Ugurlu Dam Lakes (6,7) (HUBG), two stations for each lake; and finally two of them (8K and 8T) (BG) were located on the Tozanlı and Kelkit branches flowing into Hasan Ugurlu Dam Lake after joining to each other near Erbaa, district of Tokat (Figure 1).

The study area contains 2 dam lakes, Suat and Hasan Uğurlu, as well as the river sections below and above the dam lakes (Figure 1). Originating at the Mount Kose to the east, the Yeşilırmak River continues to flow through Canik Mountain and

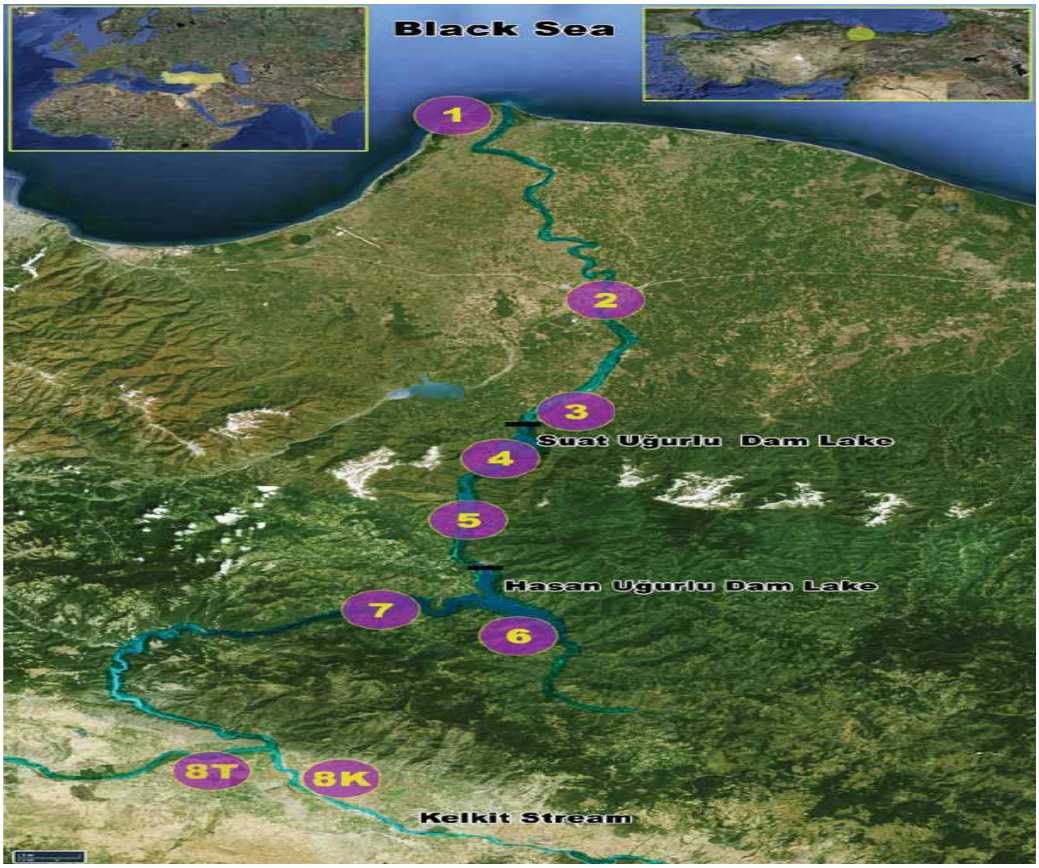


FIGURE 1
Study area

passes through the Carşamba Prairie, spreading out there, and then flows into the Black Sea. The River, 519 km in length, consists of the confluence of 3 main tributaries: The Kelkit, Çekerek and Tozanlı streams. There are 5 power plants on the river, namely Kılıckaya on the Kelkit Streams, Ataköy and Almus on the Tozanlı Stream, and Suat and Hasan Uğurlu on the river near the mouth. Suat Uğurlu Dam Lake is located at the latitude of 41°03′N and the longitude of 36°40′E (Figure 1). It is 60 m above sea level. The reservoir has a maximum depth of 25 m, a length of 382 m, and a surface area of 10 km^2. The maximum inflow (5×107 m^3 s^{-1}) to the reservoir occurs in spring and the minimum (25 m^3 s^{-1}) in fall. The reservoir was created in 1982 for irrigation and power generation.

Sampling protocols and water analysis. Water samples were collected seasonally between April 2008 and July 2009 at 9 sites located along the river and dam lakes built on the river. Water samples in dam lakes and deep river sites (Sites 1 and 8K) were collected by Vondorn bottle [17]. For each sample, water samples were carried in ice-blocks in cold box and analyzed in a Laboratory at the Department of Fisheries and Aquaculture, Gazi-osmanpasa University.

Water temperature, dissolved oxygen, salinity and conductivity were measured with an YSI-85 water quality meter. The other parameters such as turbidity, salinity, pH, electrical conductivity and nutrients like nitrite, nitrate, ammonium and Orto-phosphate were measured with a WTW Photo flex Turb-Photometer in the field and the laboratory of Faculty of Agriculture in GOP University. Water flow speed was determined with a current meter (Global Water Brand FP 201 model). Fish samples were supplied with gill nets in lake stations and net fishing and electro-shock device in river stations.

RESULTS AND DISCUSSION

Physico-chemical water quality parameters. Water temperature ranged from 6.8 (February 2009-Station 6) to 29.4 °C (July 2008 Tozanlı, Station 8) with a mean of 16.96 °C along the study. Mean water temperature between stations differed statistically ($F_{8.40}$=3.50; P=0.038) (Table 1 and 2). Mean water temperature of station-3 at the exit of Suat Ugurlu Dam Lake (14.87 °C) was statistically different from the temperature of station-6 and 7 (18.95 °C and 19.07 °C). Mean water temperature was significantly different between months ($F_{5.40}$=89.89; P=0.001). The highest mean water temperature was in July 2008 and 2009 and the lowest mean 8.42 °C in February 2009. It was determined that there was a significant correlation

between water temperature and some environmental water parameters like electrical conductivity (r=0.56; P=0.000), pH (r=0.28; P=0.042), dissolved oxygen (r=-0.35; P=0.009), NO_2-N (r=0.31; P=0.021); NH_4-N (r=0.53; P=0.000) and Chlorophyll-a (r=0.38; P=0.004) (Figure 2).

The current velocity reached the highest value (2.00 m s^{-1}) at the station below the Suat Uğurlu Dam Lake and lowest value (0 m s^{-1}) (November 2008, Station 1) in the river section opening to the Black Sea (Table 1 and 2). The mean current velocity during the study period was 0.76 m s^{-1}. According to the results of statistically analysis of data, water current velocity showed meaningful difference between both stations and months. The recorded mean current velocity in 2008 (0.89 ms^{-1}) was determined higher than that of other months ($F_{8.40}$=10.14; P=0.001). Mean current velocity in all riverine stations was different statistically. There was a significant correlation between current velocity (r=0.48; P=0.008) and the parameters of dissolved oxygen and NO_3-N (r=0.47; P=0.009) (Figure 2).

The water depth in the dam lakes ranged from 8 m (July 2009) to 100 m (Station 7) with a mean value of 46.35 m, while water depth in the river sites ranged from 0.41 (November 2008-Tozanlı) to 4 m (July-Station 1) with a mean value of 1.63 m (Table 1 and 2). The depth was analyzed with non-parametric Friedman test because the depth data were not normally distributed. Although the depth of Station-7 in Hasan Ugurlu Dam Lake was different statistically than those of the stations in other dam lakes, it was determined that the depths of stations in other dam lake was different (S=43.13; P=0.000). The depths of riverine stations were statistically different from the other. The depths of stations according to the months have not showed any difference (S=43.17; P=0.000). There was a significant correlation between the depth and only pH as a recorded environmental parameter (r=0.39; P=0.004) (Figure 2).

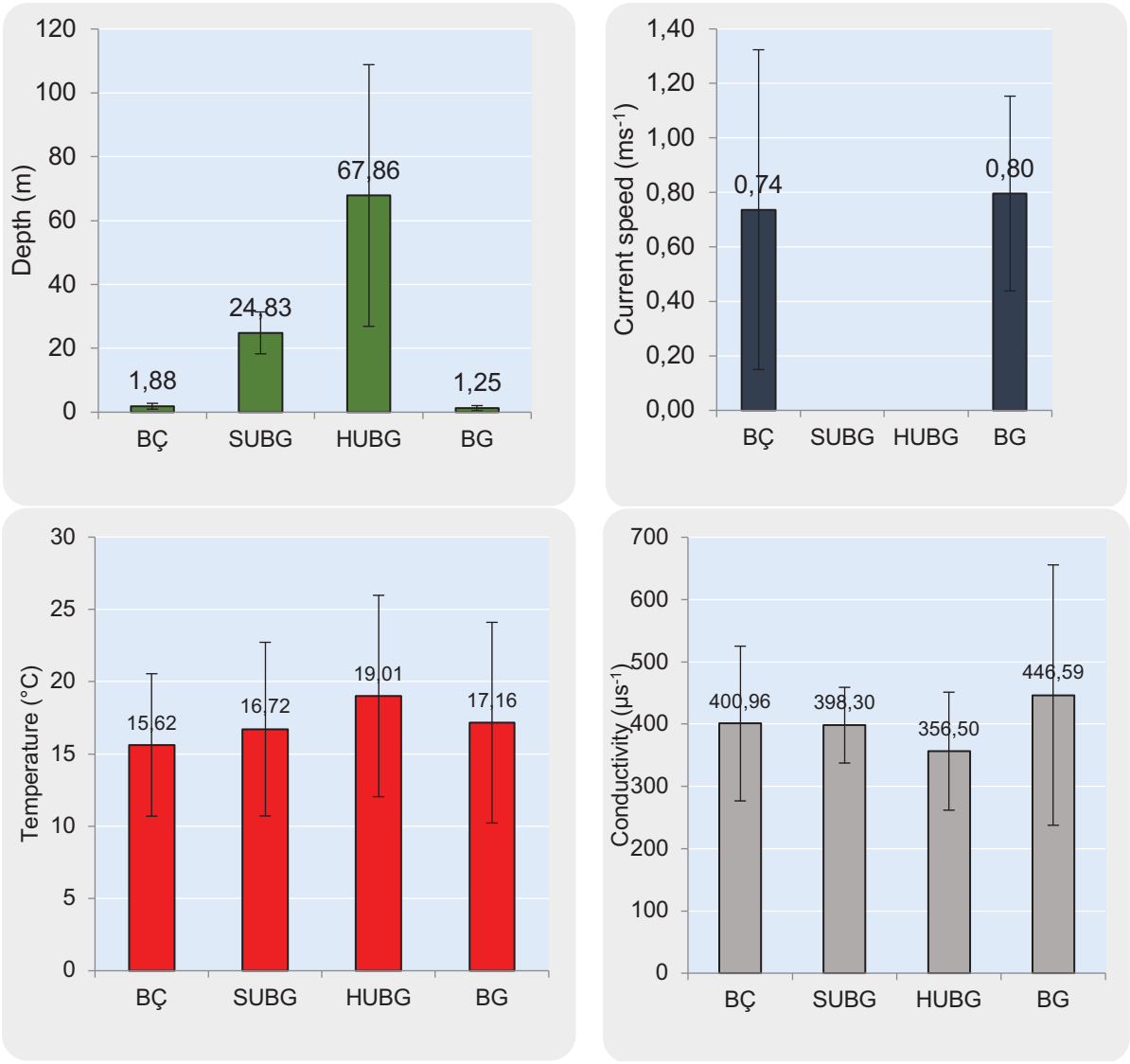


FIGURE 2
Comparison of some parameters between dam and riverine sites

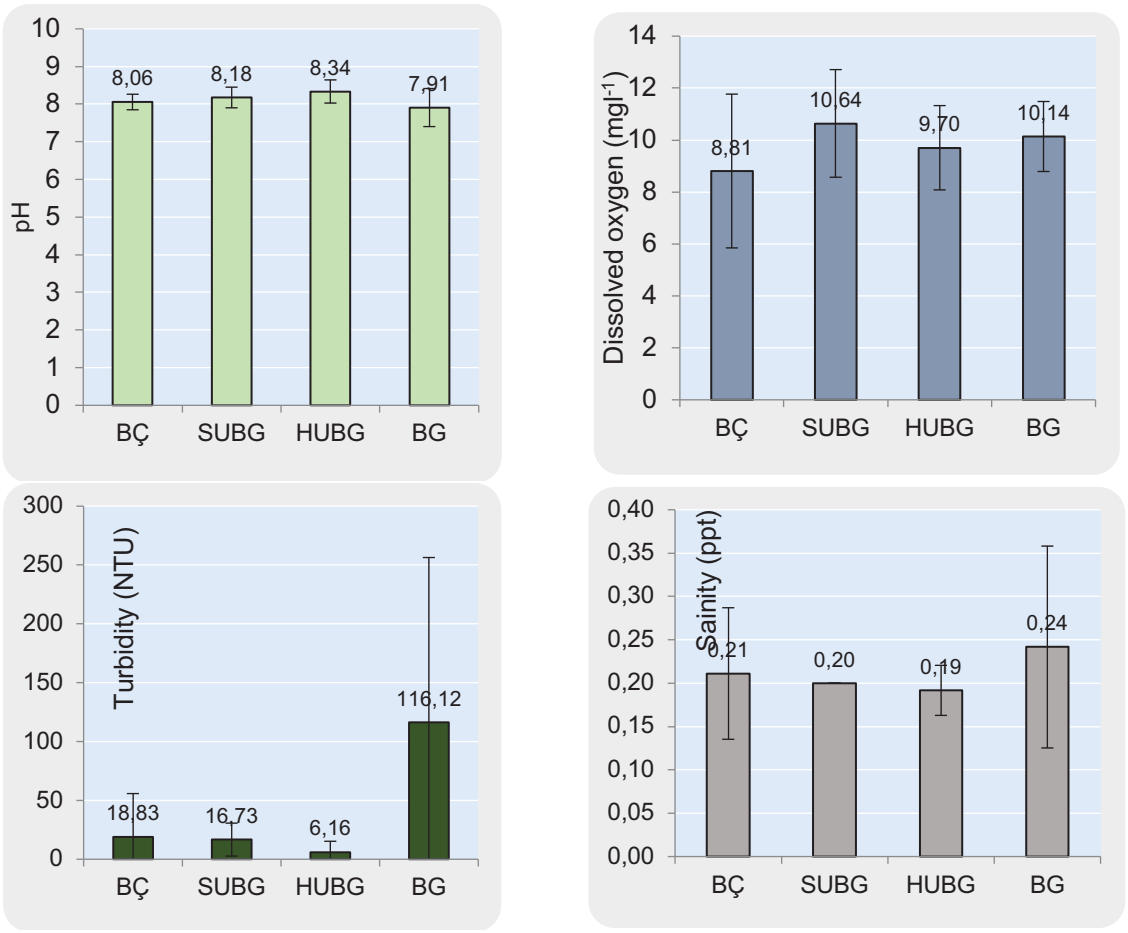


FIGURE 3
Comparison of parameters between dam and riverine sites

TABLE 1
Average value of environmental data range and statistics for all stations

Parameters	Depth (m)	Flow speed (m/s)	Temperature (°C)	Conductivity (µs)	pH	Salinity (ppt)	Dissolved O_2 (mgl^{-1})	Dissolved O_2 (%)	Turbidity (NTU)	NO_3-N (mgl^{-1})	NO_3 (mgl^{-1})	NO_2-N (mgl^{-1})	NO_2 (mgl^{-1})	NH_4-N (mgl^{-1})	NH_4 (mgl^{-1})	PO_4-P (mgl^{-1})	PO_4 (mgl^{-1})	Chlorophyll-a (μgl^{-1})
Max.	30.2	1.60	24.47	532.62	8.50	0.27	11.54	124.7	118.7	1.76	7.81	0.04	0.14	0.92	1.21	1.65	12.7	25.2
Mean	21.5	0.76	16.96	400.63	8.11	0.21	9.71	98.37	37.17	0.30	1.33	0.03	0.08	0.53	0.67	0.87	2.91	8.19
Min	13.6	0.28	8.41	234.16	7.73	0.14	7.54	73.48	5.41	0.00	0.00	0.02	0.03	0.19	0.21	0.32	0.91	0.79
S.D.	7.98	0.50	6.35	112.26	0.32	0.05	2.10	19.00	44.28	0.72	3.20	0.01	0.04	0.30	0.38	0.53	1.99	9.82

TABLE 2
Average value of annually environmental data for each stations

Parameters	Depth (m)	Flow speed (m/s)	Temperature (°C)	Conductivity (µs)	pH	Salinity (ppt)	Dissolved O_2 (mgl^{-1})	Dissolved O_2 (%)	Turbidity (NTU)	NO_3-N (mgl^{-1})	NO_3 (mgl^{-1})	NO_2-N (mgl^{-1})	NO_2 (mgl^{-1})	NH_4-N (mgl^{-1})	NH_4 (mgl^{-1})	PO_4-P (mgl^{-1})	PO_4 (mgl^{-1})	Chlorophyll-a (μgl^{-1})
Sts.																		
1	2.12	0.60	15.85	475	8.02	0.26	7.79	76.30	14.99	0.00	0.01	0.02	0.05	0.71	0.90	0.90	3.52	4.28
2	1.51	0.64	16.43	383	8.07	0.20	9.70	98.13	10.94	0.20	0.86	0.02	0.06	0.45	0.58	0.88	3.18	5.13
3	10.3	-	16.58	365	8.23	0.18	9.13	92.84	34.41	0.00	0.01	0.03	0.07	0.61	0.77	0.83	2.97	11.64
4	20.1	-	17.09	406	8.03	0.20	10.14	98.31	14.24	0.21	0.95	0.03	0.07	0.48	0.59	0.73	2.65	12.19
5	39.6	-	18.53	387	8.10	0.20	10.39	106.30	21.51	0.03	0.12	0.03	0.07	0.39	0.51	0.53	1.59	16.44
6	42.9	-	18.93	346	8.25	0.18	10.13	107.60	8.87	0.02	0.10	0.03	0.05	0.40	0.49	1.15	3.64	19.82
7	48.2	0.79	20.59	472	8.22	0.23	10.33	111.94	28.88	0.04	0.19	0.03	0.10	0.45	0.56	1.16	3.53	7.44
8T	14.2	0.77	17.86	431	7.98	0.23	9.78	102.19	87.28	0.14	0.67	0.05	0.16	0.62	0.78	0.82	2.50	4.18
8K	1.66	0.68	15.17	373	8.19	0.20	10.02	99.13	37.63	0.00	0.00	0.03	0.09	0.56	0.69	0.84	2.54	3.79

The conductivity value varied from 105.40 (February 2008, Station 6) to 819.50 µS (November 2008, Station 1) with a mean value of 407.33 µS. Mean conductivity had a statistical difference between stations (S=20.18; P=0.010). The highest (542.74 μs^{-1}) and the lowest (320.12 μs^{-1}) mean conductivity were recorded in Tozanlı (Station 8) and in Hasan Ugurlu Dam Lake (Station 6) (Table 1 and 2). Although the difference between these stations was statistically significant, there was no difference between the other stations. The difference between mean conductivity belonging to months were statistically significant (S=28.68; P=0,000). It was determined that the difference between the highest mean conductivity (483.78 μs^{-1}) (July 2009) and the lowest mean conductivity (290.66 μs^{-1}) (February 2009) was statistically significant. Mean conductivity in summer times were higher than autumn and spring generally. There is a significant correlation between salinity, conductivity (r=0.88; P=0.000) and dissolved oxygen (r=-0.41; P=0.002) as expected (Figure 2).

The maximum, minimum, and mean pH values were 8.84 (April, 2008; Station 6), 6.95 (April, 2008; Station 8), and 8.11, respectively. pH value did not vary much among the sites (Table 1 and 2). The pH value of an aquatic medium should not exceed the limits as 6.5-8.5 due to being usable for aquaculture and no threat for aquatic life [18]. While low pH values were determined in autumn, winter and spring seasons generally, it showed an increase in summer times, comparatively. pH values in the stations of dams were higher than those of riverine sites. But there were no statistically significant variations between stations and months ($F_{8,40}$= 1.28; P=0.2804 stations, $F_{5,40}$=1.05; P=0.4009). And there were also positive correlations between pH and depth, turbidity (r=-0.67; P=0.000) and NH_4-N (r=-0.28; P=0.037). According to monitoring of pH, the water of study area had an alkaline character (pH: 8.11) and an appropriate life medium for fish (Figure 3).

The water during the study exhibited freshwater features, with salinity ranging from 0.00 (November 2008; Station 9) to 0.50 ppt (November 2008; Station 1), with a mean value of 0.21 ppt (Table 1 and 2). There were no significant variations between stations ($F_{8.40}$=1.94; P=0.0802) although the highest salinity (0.30 ppt) concentrations in Station 8 and the lowest salinity (0.18 ppt) in Station 3 were obtained. Although the highest mean salinity (0.23 ppt) in July 2009 and the lowest mean salinity (0.19 ppt) were recorded, this variation was not statistically significant ($F_{5.40}$=1.94; P=0.7959). Salinity concentration that decreases the dissolved oxygen saturation had only positive correlation with dissolved oxygen in water (r=-0.35; P=0.009). The highest salinity was measured in river mouth (Station-1) due to marine water effects and domestic and sugar refinery waste water in other points (Figure 3).

Dissolved oxygen in water is required as 9.2-11.5 mgL^{-1} for Salmonids and as 5.00-9.00 mgL^{-1} for Cyprinids (Çelikkale, 1994). On the other hand, it has been advised that the lowest dissolved oxygen concentration should not be below 6 mgl^{-1} in freshwater medium (US EPA). Dissolved oxygen reached the maximum concentration of 14.80 mgL^{-1} and minimum concentration of 0.05 mgL^{-1} (November 2008; Station 1), with a mean value of 9.71 mg L^{-1} (Table 1 and 2). In general, while mean dissolved oxygen concentration in winter, spring and at the beginning of summer (June 2009) was high comparatively, the lower level of dissolved oxygen was recorded in summer and autumn months. In these seasons, the decrease in water level and the increase in water temperature could decrease the dissolved oxygen in water. This variation was described as statistically significant (S=21.25; P=0.001). Although the highest mean dissolved oxygen concentration was obtained in Suat Uğurlu Dam Lake's stations, Tozanlı and Kelkit riverine stations and the lowest mean dissolved oxygen concentration in 1st station, the mean dissolved oxygen variations between stations were not significant (S=9.12; P=0.332). It was determined that the dissolved oxygen has a positive correlation with temperature and salinity (r=-0.35; P=0.009) comparatively (Figure 3).

According to observations when the lowest dissolved oxygen conditions (0.55 mgL^{-1} and station 1); process water of the nearby sugar factory station that left directly across the river without subjecting any processing, station 1,2 and 3 is that the upper portion located closed to obtain long-term power of the Suat Ugurlu floodgates and it was observed that water left. It was even observed in the salinity measurements that the saline water came from the mouth of the river because of the decrease in water level at 1st station. Except for such anthropogenic effects and the occlusion of dam covers, dissolved oxygen conditions are not likely to threaten living life or even provide optimal conditions. As a matter of fact, the average dissolved oxygen content did not fall below 8 mgL^{-1} both seasonally and between stations except for the 1st station (Figure 3).

During the study, the turbidity value varied between 37.17 NTU average between 0.18 NTU (July 2008 station 7) and 418.10 NTU (April 2008 8th Station). The highest mean turbidity value was determined at 8th and 9th stations (141.93 NTU and 90.31 NTU) while the lowest value (3.95 NTU) was detected at 7th station in Hasan Ugurlu Dam Lake (Table 1 and 2). Stations 8 and 9 are located in the study area ahead of the dams and are named as Tozanlı and Kelkit. These rivers bring home wastes and rainwater of the settlements they call. These streams combine to form the Yeşilırmak. Both of them are observable from the land observations that

the deposits are high rivers and their beds are quite large. Therefore, the highest turbidity values were recorded at these stations. On the other hand, because of the decrease in the flow rate at the dam stations and the formation of a large mass of water and lake, suspended sediments are precipitated and the turbidity decreases, even the lowest turbidity values are recorded. While the difference between these two stations was statistically different, no statistical difference was found between the other stations (S=33.60; P=0.002). The difference between the mean turbidity values of the months was statistically different (S = 19.35, P = 0.000) as it was at stations. The highest average value between the months (91.40 NTU) was reached in April 2008 and the lowest average value was reached in July 2008. Naturally Turbidity values generally increase in rainy seasons, while the lowest values are found in arid summer months. Turbidity was found to have a significant correlation with the measured parameters only with $N0_2$-N (r = 0.46; P = 0.002) (Figure 3).

Nitrate nitrogen (NO_3-N) varied from 0 to 7.40 mgl^{-1} (April 2008 5th Station) throughout the study with an average of 0.33 mgl^{-1} (Table 1 and 2). T.C. Water Pollution and Control Regulation According to the Continental Water Resources Classification system, the average and highest Nitrate nitrogen values indicate first class water quality grades and it is stated that they can be used as drinking water, animal production and agricultural irrigation source in order to process water resources having these standards. There was no statistically significant difference between mean values of stations and months (S = 2.28; P = 0.971). NO_3-N has not been found to have a significant correlation with any of the measured environment (Figure 4).

Nitrite nitrogen (NO_2-N) varied from 0.0 mgL^{-1} (November 2008 station 1) to 0.10 mgl^{-1} with an average of 0.03 mgl^{-1}. The highest mean nitrite nitrogen concentration (0.038 mgL^{-1}) was recorded in April 2008, while the lowest value (0.024 mgL^{-1}) was recorded in July 2008 (Table 1 and 2). When the average nitrite nitrogen values are evaluated according to the Continental Water Quality Standards, the second class water quality standard emerges. Seasonal nitrate nitrogen concentration values did not fall below the second grade water quality class in all study periods (Figure 4).

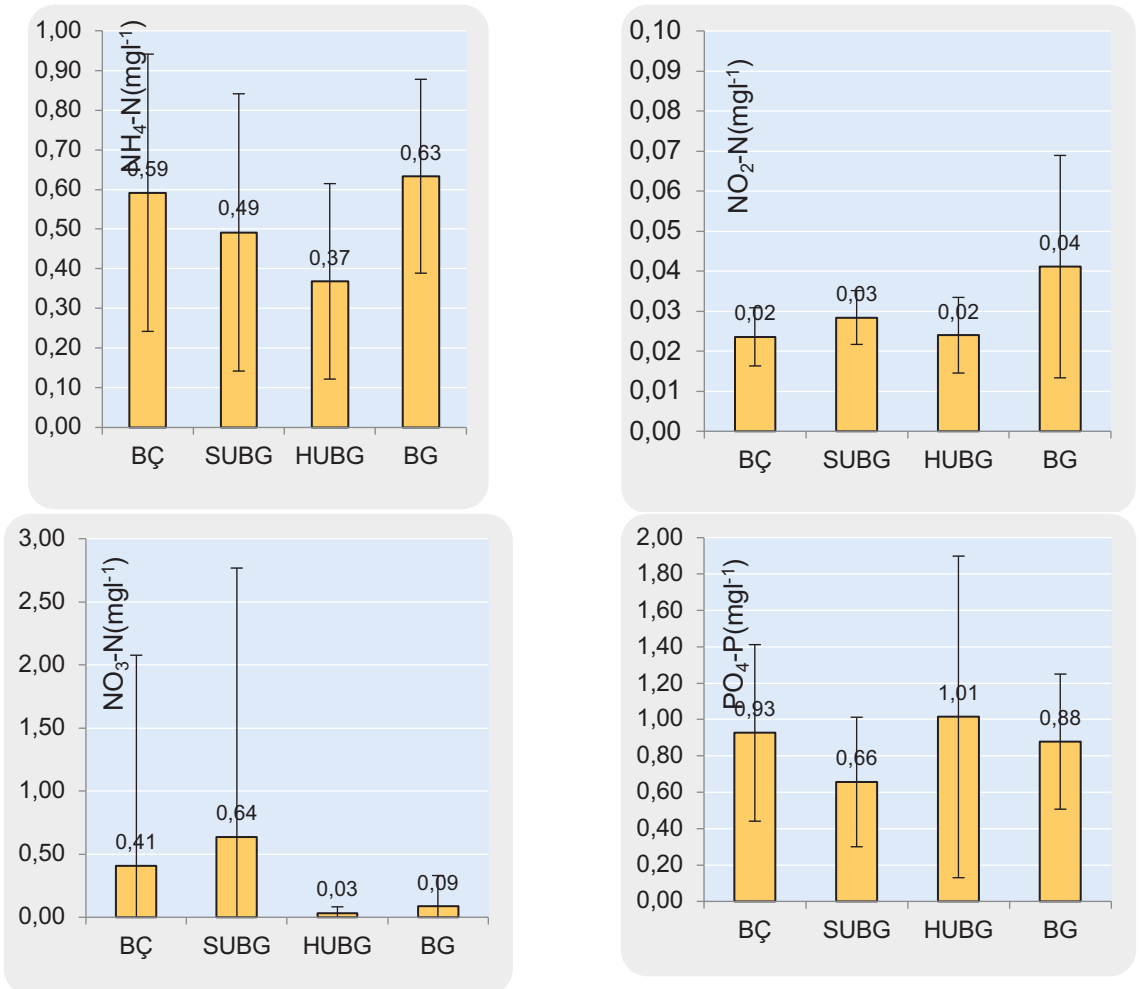


FIGURE 4
Comparison of nutrients between dam and riverine sites

This change between monthly average values was not statistically different ($F_{5.40}$=1.11; P=0.3692). According to the stations, the highest mean value was obtained at the 8th station (0.06 mgl^{-1}) and the lowest value was obtained at the 1st station (0.02 mgL^{-1}). Only the water quality values of Tozanli Stream are at the 3rd grade level in terms of nitrite nitrogen, while the second grade water quality class is mentioned at other stations. It can be argued that this situation may be caused by municipal wastewater and rain water which sweeps agricultural land. This change in stations was statistically significant ($F_{8.40}$=3.91, P=0.0017). 8. Although the average value of the station was determined differently from the average values of all other stations, it did not show any statistical difference between the average values of the other stations. It has been found that nitrate nitrogen has a significant correlation with ammonium nitrogen (NH_4-N) (r=0.992; P=0.000) and Ortho-phosphate phosphorus (PO_4-P) (r=0.329; P=0.015) (Figure 4).

Ammonium nitrogen (NH_4-N) varied from 0.02 mgl^{-1} (November 2008 stations 5 and 7) to 1.30 mgl^{-1} with an average of 0.53 during the study period. The highest concentration (0.89 mgL^{-1}) of the average ammonium nitrogen concentration was found in February 2008, the lowest (0.26 mgl^{-1}) average was in June 2009 (Table 1 and 2). According to the Water Quality Standards of the Continent, it is evaluated that the water quality class is 1st grade according to the average values in terms of ammonium nitrogen. The values measured according to the seasonal changes and stations show the first grade. The mean concentration in February was found to be greater than the mean concentrations in other months ($F_{5,40}$ = 8.34; P = 0.0001). A mean concentration of the highest (0.73 mgl^{-1}) was found at the 8th station, while the lowest concentration (0.35 mgl^{-1}) was found at the 6th station, but no statistical difference was found between the average concentration values of the stations ($F_{5,40}$=8.34; P = 0.0001). Ammonium nitrogen was found to have a significant correlation with only orthophosphate phosphorus (r=-0.34; P=0.012) (Figure 4).

Nitrogen compounds, in terms of environmental water quality, also contain toxic compounds as well as disrupting oxygen balance. In terms of Ammonium Nitrogen with the most toxic characteristic, the 2nd grade water quality (Clean) character is appeared predominantly in terms of Nitrite nitrogen which is toxic to the 2nd place in all the stations in the study area which contains 1st grade water quality (Very clean). In terms of nitrate nitrogen, which has the lowest level of toxicity, there is no significant environmental problem because first class water quality is seen. Therefore, it can be said that there is no critical anthropogenic effect in terms of nitrogen compounds in stations representing the study area on Yeşilırmak. Orthophosphate phosphorus (PO_4-P) was changed between 0.06 mgl-1 (November 2008 7th Station) and 2.80 mgl^{-1} (February 2009 7th Station) throughout the study with an average value of 0.88 mgl^{-1}. According to the continental water quality standards Orthophosphate phosphorus in general, a very dirty water quality standards have been caught in the fourth class. The highest average phosphorus (1.24 mgl^{-1}) and the lowest (0.63 mgl^{-1}) phosphorus were determined in February and July 2009, respectively. However, this change in stations was not statistically different ($F_{5,40}$=1.24, P=0.3074). Similarly, with the highest mean concentration (1.1 mgl^{-1}), the lowest value (0.59 mgl^{-1}) was found in the 6th station 5. The mean values of the stations were not statistically different ($F_{8,40}$=1.24, P=0.9005). The water quality standard, which is expressed as very polluted in terms of orthophosphate phosphorus, clearly indicates the effects of domestic wastewater containing detergent pollution. It is observed that this situation applies to all stations and all seasons (Figure 4).

Spatial Distribution of Fish Species Number. During the study, it was determined that the 3rd station had 20 different fish species and the most fish species, while the other stations contained 7 to 9 fish species. In general, it has been determined that the number of fish species in river areas is relatively higher than that in dam lakes (Figure 5). The average number of species also showed a similar change in stations. It has been determined that the highest average fish species has the third station (9.33) and the lowest average fish species has the second station (2.16). This spatial variation of the average number of species was statistically significant ($F_{8,40}$=6.19). The average number of species in the third station was not different from the number of species in the second, fifth and sixth stations (Figure 5).

Principal Component Analysis of Water Quality Data (PCA). We applied the PCA test to determine the impact of human-generated habitat change on water quality such as a dam. The principal component analysis revealed four components that account for 92% of the variation in environmental parameters. The first component (PC1) explained 53.6% of the changes occurring in the data and the second component revealed 20%. These two components accounted for 73.6% of the total change in the data (Table 3).

From the parameters, depth, flow velocity and turbidity were the most important parameters (higher than 0.60) describing the changes that took place throughout the first component. Among other parameters, pH, chlorophyll-a, water temperature and nitrate nitrogen were identified as other important factors explaining the changes occurring throughout this component. The PCA 1 has separated the deep dam lake stations (4, 5, 6, and 7) from the river stations. PCA 1 axis, which is positively associated

with flow velocity and turbidity, distinguishes river areas where these characteristics predominate from other stations. If Figure 6 is considered as four equal panels, the first panel (+, +) in the upper right corner will show the turbidity, flow rate and the nutrient elements and high dissolved oxygen in April (the river stations 1, 2, 3, 8 and 9) and 1st and 8th stations in June 2009; With the first 3 stations of the other months except April, where the second panel in the lower right corner contains again flow rate, turbidity and temperature, conductivity and chlorophyll-a, November and July 2008 and 2009, 8th and 9th stations, panel on bottom left corner shows depth, pH and high temperature and chlorophyll-a in June and July 2008-2009 of 4th, 5th and 6th stations; 4th panel on the left upper corner represents in June, November and February of 4th and 5th stations and 6th and 7th stations belonging to April, June and February (Table 3) (Figure 6).

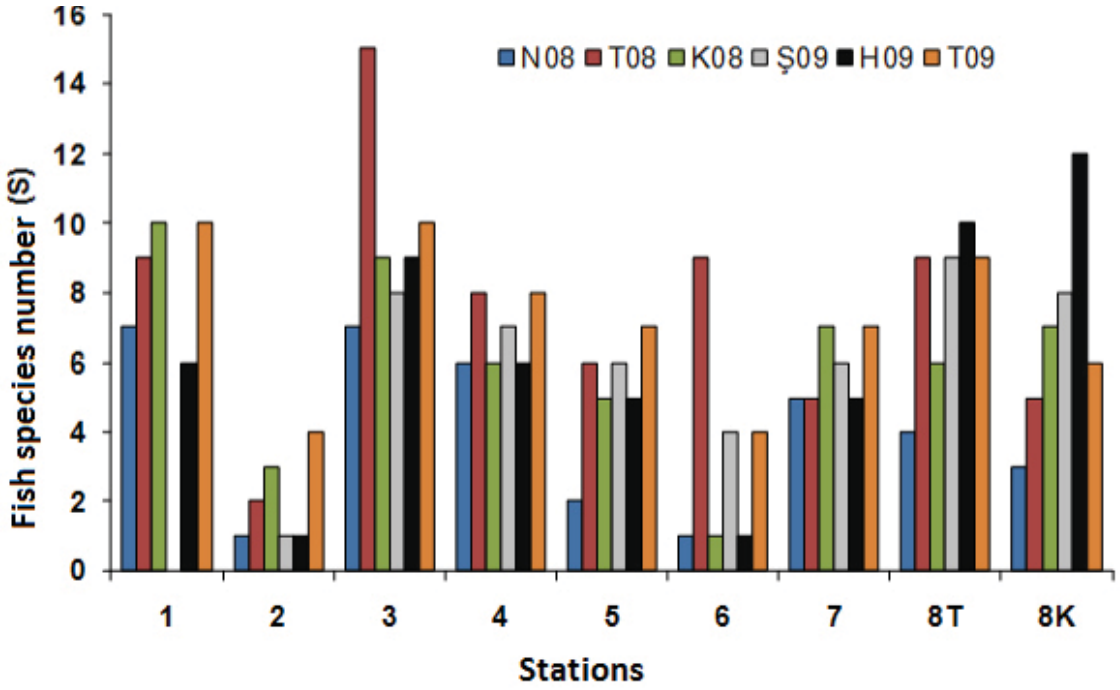


FIGURE 5
Change of total number of fish species according to stations

TABLE 3
The results of Principal Component Analysis of water quality data

Components	PC1	PC2	PC3	PC4	Total variation
Eigenvalue	0.536	0.199	0.143	0.042	1.000
Cumulative % variation of data	53.60	73.60	87.90	92.10	

Parameters	Principal Components			
	PC1	PC2	PC3	PC4
Depth	**-0.89**	0.41	0.19	-0.01
Flow speed	**0.73**	-0.08	-0.21	-0.07
Water temperature	-0.34	**-0.56**	0.25	-0.50
Electrical conductivity	-0.05	-0.22	0.27	**-0.88**
pH	**-0.57**	-0.25	-0.14	0.14
Salinity	0.14	-0.09	0.20	**-0.78**
Dissolved oxygen (DO)	0.01	0.27	0.12	0.47
Turbidity	**0.80**	0.31	0.51	0.00
$N0_3$-N	0.05	0.24	-0.31	0.06
$N0_2$-N	0.31	0.24	0.13	0.05
NH_4-N	0.40	0.16	0.05	0.16
$P0_4$-P	0.15	0.06	-0.11	0.26
Chlorophyll-a	-0.48	**-0.70**	0.51	0.12

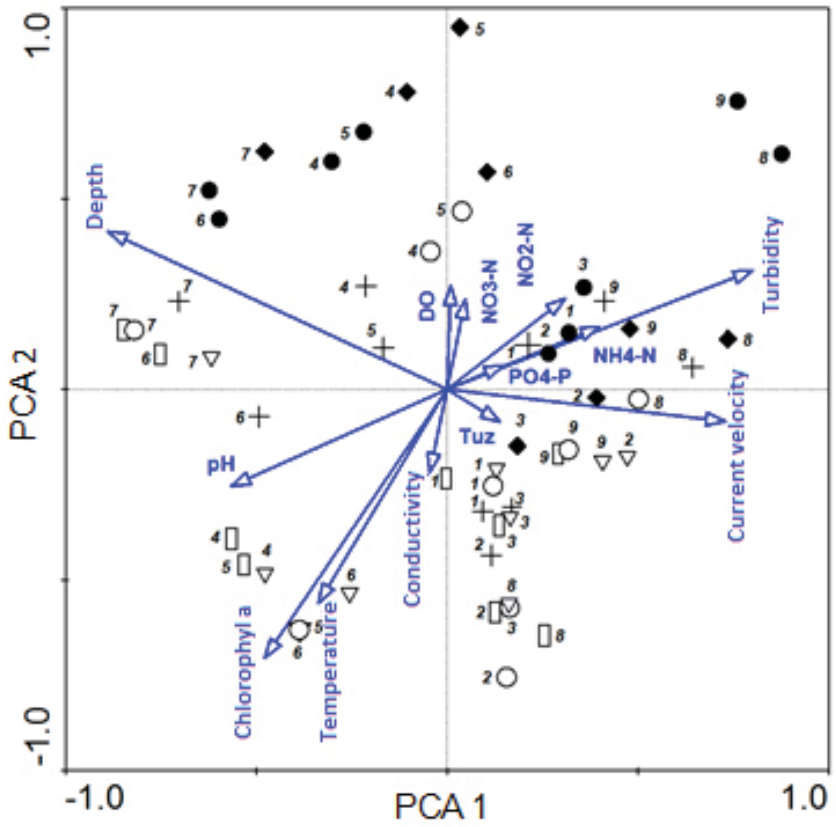


FIGURE 6

Analysis of basic components of environmental parameters. The numbers under the signs indicate the stations. It is 9 8K from the stations and the 8th figure is 8T. Circular mark November 2008, full circular mark April 2008, baklava slice full sign February 2009, + sign June 2009, hollow triangle sign July 2009 and hollow rectangular sign July 2008.

CONCLUSIONS

In general, it has been determined that the number of fish species in river areas is relatively higher than that in dam lakes (Figure 5). The average number of species also showed a similar change in stations. It has been determined that the highest average fish species has the third station (9.33) and the lowest average fish species has the second station (2.16). This spatial variation of the average number of species was statistically significant ($F_{8,40}$=6.19). Same results were reported by many researchers that the reservoirs have generally much more species than the riverine environments it replaces [1, 19, 20]. Wang et al. (2011) found that environmental factors that influence fish assemblages in addition to dams should be incorporated when evaluating regional effects of dams on fish assemblages [21]. On the other hand, they explained that the role of dams alone in determining fish assemblages at a regional spatial scale is relatively small (explained less than 20% of variance) compared with the other environmental factors, such as river size, flow and thermal regimes and land uses jointly. However, their results do demonstrate that downstream and upstream dams can substantially modify fish assemblages in the non-impoundment sections of rivers. After excluding river size and land-use influences, their results clearly demonstrate that dams have significant impacts on fish biotic-integrity and habitat-and-social-preference indicators.

A study in the headwaters of the Lancang-Mekong River in the south-western Himalaya Mountains (Qinghai-Tibetan Plateau, China) has been showed that dam construction and operation has various impacts on water quality and water self-purification capacity of different segments in different periods. In general, the construction of Manwan Dam negatively affected the water self-purification capacity of reservoir and below-dam segment but impose little impact on that of downstream flowing segment [8]. In this study where the water quality changes in the river Yeşilırmak was examined due to the construction of two different dams on the river as a habitat change, the difference in depth and flow speed between the river and the lake stations is certainly not discussed. In both habitats it is highly probable that the number and species of live individuals are different. Because when the water is stagnant and deep in the lake stations, the river stations are relatively deep and

the water flow is fast (Figure 2). However, this is not the case in terms of pH, dissolved oxygen and salinity (Figure 3). On the other hand, there are significant differences in terms of turbidity (Figure 2) and nutrients (nitrogen and phosphate) (Figure 3) in two different habitats.

Principal Component Analysis, which is used to determine the risk factors that are important in the formation of water quality and pollution of water resources, is a statistical evaluation method which is applied by many researchers [22, 23, 24, 25]. In terms of physico-chemical water quality variables, the principle component analysis (PCA) was applied to the existing data for determining the differences between lake and river stations in this study. According to the results of PCA analysis on physico-chemical water quality data; water depth and flow velocity are primary components in the separation of dam lakes and river stations. pH, chlorophyll-a, water temperature and nitrate nitrogen parameters are secondary water quality components when these two different environments are evaluated for aquatic life. Differences between dam reservoir and river stations are very important in terms of primary basic components. On the other hand, in terms of depth, pH, temperature and chlorophyll-a parameters, dam reservoir stations can be separated significantly from river stations.

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