

# ASSESSMENT OF WATER QUALITY AND FISHERIES ACTIVITIES IN UPPER AKCAY RIVER IN DENIZLI-MUGLA PROVINCE

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## ABSTRACT

Upper Akcay River (Denizli-Mugla, Turkey) is located in Mugla and Denizli province from Buyuk Menderes Basin, in Southern part of Turkey. Kemer Dam Lake separates the river from the downstream and prevents the fish passages. Akcay River is important for aquaculture activities, irrigation and fisheries activities. In upper Akcay River have many threats which affect the study area these are pollution of agricultural and domestic activities, fishing pressure, habitat degradation, over-abstraction of water and barriers.

The study was conducted to assess the physical and chemical water quality parameters and fisheries activities of upper Akcay River. The upper Akcay River goes through Kemer Dam Lake, in this river fisheries and aquaculture are practice. This study was carried out between June 2012 and May 2013. Water samples were taken in three stations from upper Akcay River and were analyzed for water temperature, pH, dissolved oxygen, electrical conductivity, ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, and orthophosphate. In this study, fish samples were collected by electrofishing and cast net from tree station from the river.

River water quality is important because it is used for domestic purpose, drinking, irrigation and aquatic activity. The upper Akcay River is one of the most prominent and a sensitive region that is not too exposed to human effects in Buyuk Menderes Basin. The river can play a vital role in contributing to social economic and development.

This study describes the water quality assessment of upper Akcay River in the Southwestern Anatolia. The mean values of overall water quality parameters results have been observed as water temperature (15.15 °C), pH (7.58), conductivity (555.25 µS/cm), TDS (371.44), dissolved oxygen (8.56 mg/L), ammonium (0.09 mg/L), nitrate (3.84 mg/L), orto-phosphate (0.04 mg/L). The economic species caught in the river are *Onchorynchus mykiss*, *Capoeta bergamae*, *Alburnus escherichii*, *Vimba mirabilis*, *Chondrostoma meandrense*, *Squalius fellowesii*, *Barbus pectoralis* and *Carassius gibelio*.

According to the WPRA, surface water quality

of the upper River was classified as level I. At the end of the analyses, it was revealed that the areas is suitable for trout aquaculture and fisheries. The results show that, aquaculture activities has no negative affect in upper Akcay River

## KEYWORDS:

Akcay River, Aquaculture, Environmental effects, Water quality, Fisheries, Denizli, Mugla

## INTRODUCTION

Upper Akcay river is located in Southern part of Aegean Region (Turkey) in the Buyuk Menderes Basin. The River area is a private wetland and is very important for the livelihood to offer several economic benefits in region. The upper Akcay River occurs a significant and original ecosystem in terms of conservation of natural resources and biological diversity, the study area is also rich in fish and bentic fauna [1, 2].

Büyük Menderes River basin is among the 76 most important international wetlands in Turkey [3]. Kemer Dam is within the boundary of Bozdoğan District of Aydın province for irrigation, flood control and energy. The normal water level of the Dam Lake area is 14.75 km<sup>2</sup> and with volume 544 hm<sup>3</sup> volume. Degirmendere, Delicay, Bagdere, Yenidere, Mortumadere and Keklik Streams are other sources that feed the Dam lake [4].

Water quality is the most essential resource of all nutrients required by animals. The water body is plays a role anabolic and catabolic mechanism. The water mineral require for fishes are effected by some factors, such as, quality of water source, nutrient composition and environment factors [5].

The behavior and impact of contaminants in aquatic ecosystem are complex. They may involve, adsorption, precipitation-solubilization, filtration, excretion, sedimentation, resuspension and biological uptake [6]. Many contaminants, imprudent water management practices and destructive land uses threaten aquatic systems in the world. Also, it has been shown that good water quality is a critical component for sustainable socio-economic development [7].

Water pollution is defined as the destruction of natural structure of water sources. The physical, chemical and biological aspects of water quality in the determination of pollution and its effects in water is very important in terms of providing information about the currently situation of water [8]. It is possible to determine whether the water is suitable for the purpose of fish farming in lakes and rivers, by detecting the physical and chemical parameters using appropriate method [9].

The Upper Akcay River comprises 15 different fish species and 76 species benthic invertebrates. Also, the river has a high fish larvae breeding potential which is an important river ecosystem for native fish [1, 2]. However, the river started to get affected by human activity such as agriculture and domestic pollution from the close village. To date, improvement work to acquire new land for agriculture, illegal fisheries and juveniles, uncontrolled cutting and burning of reed, implementation of fish farming and increasing of sedimentation in Kemer Dam lack of water management and increasing aquaculture activity were the main disturbances in upper Akcay River ecosystem.

Anatolia is a large peninsula surrounded by Mediterranean Sea, Aegean Sea, Black Sea and Marmara Sea. Turkey has a very rich water resource potential in both marine and inland waters with 8333 km of coastline, 175 thousand km of rivers, 1 million hectare of natural lakes, 170 thousand hectares of dams, and 7 hundred small dams, which are used for local needs activity. Turkey has also a rich inland lentic waters (200 lakes, 159 dam lakes, 750 small dam lakes) and lotic systems (33 rivers) with fisheries and aquaculture potential [10]. The climate, water resources and topography along the coasts line and these occur many advantage is aquaculture sites. The inland water resources in Turkey are good for culturing different freshwater fishes.

Inland water fish and marine fish production in Turkey is about 52.71% and 47.29% respectively. Turkey also have a total of 1.935 licensed inland fish farms (with a capacity of 245.166 tons) and 418 marine aquaculture facilities (total capacity of 217.166 tons) currently [11].

In upper Akcay River and Kemer Dam, the main cultured freshwater fish species is trout, *Oncorhynchus mykiss*. The National Water Supply directorate has conducted fishery works in dam lakes, which resulted in limnological analyses of 183 dam lakes and 12 natural lakes [12].

The fisheries activities in dam lake and river is very important for economy development in rural region because they provide a valuable source of employment. Kemer Reservoir, built on a tributary of Buyuk Menderes River, is the most important source of inland aquaculture in Aydin province. In inland waters, over than 250 freshwater fish species have been reported in the inland waters of Turkey.

It is known that 30 species are endemic in Turkish inland waters [13]. In Kemer Reservoir 15 fish species were reported [14]. Also 8 alien invasive or introduced species were recorded in Menderes River basin and three endemic species were given in Kemer Reservoir [15, 16].

Gill nets, trammel net, cast nets and long lines were used for catching certain fish species in Kemer Reservoir. In artisanal economic fisheries, the most important economic species of Kemer Reservoir species are *Vimba mirabilis*, *Chondrostoma meandrense*, *Barbus pectoralis*, *Capoeta bergamae*, *Cyprinus carpio*, *Carassius gibelio*. In Kemer Reservoir, Fisheries yielded approximately 62 tons/year [2, 14, 15].

The studies in different regions for freshwater fish fauna in Turkey were mostly on taxonomy and ecology from researchers as Wildekamp et al. [17], Sasi [18], Sari and Bilecenoglu [19], Barlas and Dirican [20], Ilhan et al. [21], Innal and Erk'akan [22], Ugurlu and Polat [23], Yegen et al. [24], Sasi and Berber [25], Bostanci et al. [26], Gul et al. [27].

The maintenance of water quality rivers is essential for aquatic life and fisheries, because it is important for significant capability in fish breeding distribution and fisheries of the upper Akcay River. This study was to assess the water quality of the upper Akcay River and evaluate of fisheries activities.

## MATERIALS AND METHODS

**The Study Area.** Upper Akcay River is separated from Kemer Reservoir, which was built for the General Directorate of State Hydraulic Works (DSI) with a 180.50 m-high dam in 1954-58. This Dam is use for irrigation, flood control, hydroelectric purposes and fisheries activities. The hydroelectric station was constructed with an expected capacity of 143 GWh/year. This dam lake is separated from downstream and upper Akcay River created private ecosystem from the lower part of Buyuk Menderes River part is a high number of pollution due to industrial and agriculture activity and human activity.

The study was conducted at three stations in a river from South-western part Anatolia as upper Akcay River, between June 2012 and May 2013.

Akcay emerges from the mountains in the North-east of Mugla. Akcay is a high-flowing stream, which is derived from the Bozdağ and Sandraz mountains from Beyagac district of Mugla province. Beyagac (Eskere) Plain passes through other sources. Tavas takes the Yenidere Stream, which is located near Kızılcaboluk and feeds the Kemer Dam in Aydin, Bozdogan district.

Akcay joins Yenidere Stream from the slopes facing Tavas Plain. It begins to flow rapidly in narrow and deep valleys. Near the Bozdogan, be-

fore the lowland level and feeds Kemer Dam in Aydın, Bozdogan District. It crosses the valley between Karincalidag and Madran towards Northwest of Yenipazar. Akcay reaches a length of approximately 116 km. Upper Akcay River flows in the area that is not so much exposed to excessive population pressure [28].

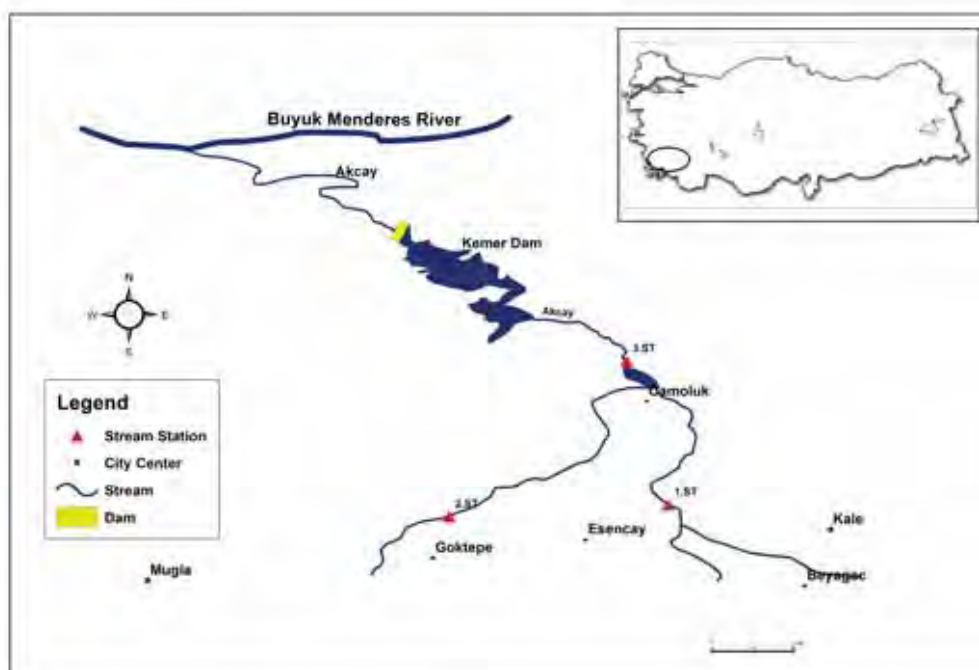
**Sampling Methods.** Water samples were collected from 3 stations (Esencay, Goktepe and Camoluk) from the upper akcay River (Figure 1). Esencay (Station 1) as used a reference station because it is not effected from human activities. 1<sup>st</sup> station coordinates are 37°24' N and 28°27'W. This area is the main freshwater input. The coming water to the river in the early summer is used for fields irrigation, because of the water level to decrease in summer. The first station is little sloping, and the water flow is slow from late spring to winter. The bottom of 1. Station is covered with sandstone and gravel.

Goktepe (Station 2) is a branch of the river that passes near a small village, with a small trout

farm in the upper part. The 2<sup>nd</sup> station coordinates are 37°27' N and 28°35'W. The bed flow of the river is sloping and covered with gravel and small rocks, and this make water flow faster.

Camoluk (Station 3) is located after the Goktepe and Esencay junction points, in the spring the water level of Kemer Dam reach to the station with excessive rainfall. The 3<sup>rd</sup> station coordinates are 37°20' N and 28°22'W. Some part of Camoluk is covered with clay and mud bottom.

Samplings were carried on monthly between June 2012 and May 2013. For every sampling; temperature, pH, electric conductivity, TDS and dissolved oxygen (DO) (mg/L) were measured directly on the field with MultiProb (YSI 556 MPS). A sample of water was collected at 10-20 cm below the surface, in a 1 liter cleaned plastic Niskin bottles. After the water samples were transported to the laboratory, they were filtered through 0.45 µm pore size membrane filters and partitioned into separate aliquot. All samples were then stored at 4 °C until analysis [29].



**FIGURE 1**  
Study Area of Upper Akcay River

**TABLE 1**  
Water quality criteria according to WPCR in freshwaters [30]

Water Quality Parameters	Water Quality Classes			
	I	II	III	IV
Temperature (°C)	25	25	30	>30
pH	6.5-8.5	6.5-8.5	6.0-9.0	<6.0 and >9.0
Dissolved oxygen (mg/L)	>8	6	3	<3
Ammonium Nitrogen (mg/L)	0.2	1.0	2.0	>2.0
Nitrite Nitrogen (mg/L)	<0.01	0.06	0.12	>0.3
Nitrate Nitrogen (mg/L)	<5	10	20	>20
Ortho-phosphate phosphorus (mg/L)	<0.02	0.16	0.65	>0.65

**Analytical procedure.** Ammonium nitrogen, nitrite nitrogen, nitrate nitrogen and orthophosphate (the Anions) were analyzed by spectrophotometry with a Hach Lange Dr3900 UVVIS Spectrophotometer.

Water parameters were measured in the laboratory by, SM standard method [29]: Ammonium nitrogen by Phenate method, SM 4500-NH<sub>3</sub>-F; Nitrite nitrogen by Colorimetric method, SM 4500-NO<sub>2</sub>-B; Nitrate nitrogen by Hydrazine reduction method, SM 4500-NO<sub>3</sub>-H and Orthophosphate by Stannous chloride method, SM 4500-PD

The quality criteria of inland water resources according to relevant categories of the Water Pollution Category Registration (WPCR) are given in Table 1 [8, 30].

**Statistical Analysis.** The monthly mean parameter values for all stations were calculated and the annual trend too was analyzed. Spearman's rho test was used to assess the correlation among the parameters. The analysis Variance (ANOVA) followed by the post-hoc Tukey test was carried on to assess the differences between the values of the measured parameters among stations. A value of  $P < 0.05$  was chosen for significance.

**Fisheries Data.** Fish species were captured using electro-fishing and scoop net from all three station. Fish were fixed by 4% formaldehyde solution in the field, before taking to the laboratory. We measured fork length (FL), total weight (WT). Fish fauna was determined the status and rates of the stations are given. Fisheries data were determined by the records of provincial directorates of the Ministry of Food, Agriculture and the data obtained from fishermen throughout the year [28].

## RESULTS

In Upper Akcay River, the average, minimum and maximum ranges of water qualities parameters were determined below together with the results of ANOVA and post-hoc Tukey test (Table 2). The mean values of temperature, pH, dissolved oxygen, electrical conductivity, TDS, nitrate nitrogen and orthophosphate did not differ among the stations ( $P < 0.05$ ).

**Temperature.** The mean of water temperatures were 16.61; 14.24 and 15.07 °C at stations 1, 2 and 3, respectively. The minimum water temperature was 4.65 °C in January at station 3; the highest temperature measured 26.35 °C in August at station 1. During the study period, the mean water temperature was 16.15 °C (Table 2; Fig. 2).

According to one year data retrieved in upper Akcay River, it indicates that there is no thermal pollution. According to WPCR the water quality can be classified as I class.

**pH.** The pH values of all stations in upper Akcay River changed between 5.96 and 8.56. The mean pH was 7.58 and the annual mean pH for stations were given below station 1, 7.56; station 2, 7.59; station 3, 7.58 (Table 2; Fig. 3).

According to the values, the upper Akcay River water is slightly alkaline, also reflects the geological features of the lake surrounding area. According to WPCR the water quality of the Lake in terms of pH is classified as level I (Table 1).

**Dissolved oxygen.** The average dissolved oxygen values of the station were determined as follows; station 1, 8.63 mg L<sup>-1</sup>; station 2, 8.57 mg L<sup>-1</sup>; station 3, 8.47 mg L<sup>-1</sup>. Minimum value was

**TABLE 2**  
Physical-Chemical values of water sample from the selected 3 stations of upper Akcay River

Parameters	Unit	1.Station Mean (Range) (Min-Max)	2.Station Mean (Range)	3.Station Mean (Range)
Temperature	°C	16.61 (6.87-26.35)	14.24 (4.80-23.69)	15.07 (4.65-25.50)
pH	-	7.56 (6.49-8.56)	7.59 (5.96-8.46)	7.58 (6.50-8.41)
Dissolved Oxygen	mg L <sup>-1</sup>	8.63 (3.58-14.45)	8.57 (3,37-13,31)	8.47 (3.36-13.47)
Electrical conductivity	µS cm <sup>-1</sup>	676.83 (445-786)	527.00 (430-620)	561.83 (431-936)
TDS	mg L <sup>-1</sup>	375.25 (286-511)	362.50 (280-590)	376.58 (315-470)
Ammonium nitrogen	mg L <sup>-1</sup>	0.05 (0.01-0.14)	0.11 (0.02-0.27)	0.12 (0.03-0.40)
Nitrate nitrogen	mg L <sup>-1</sup>	3.86 (0.50- 5.20)	3.88 (0.60-5.30)	3.78 (0.70-5.00)
Ortophosphate	mg L <sup>-1</sup>	0.06 (0.01-0.30)	0.03 (0.01-0.16)	0.05 (0.01-0.19)

\*All stations in the same row are not significantly different at Tukey test ( $P > 0.05$ )

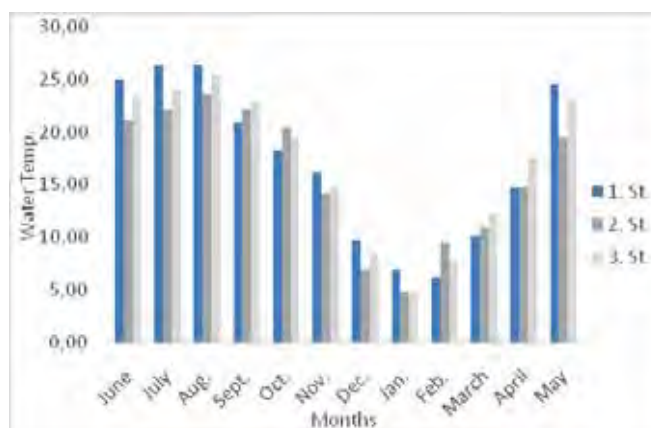


FIGURE 2

Monthly water temperature in upper Akcay River (°C)

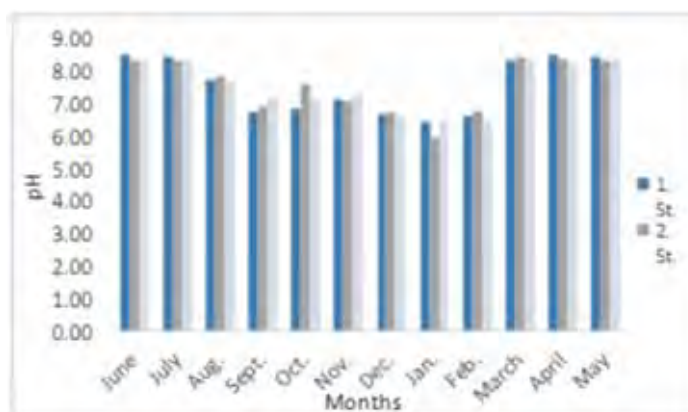


FIGURE 3

Monthly pH values in the 3 selected stations in upper Akcay River

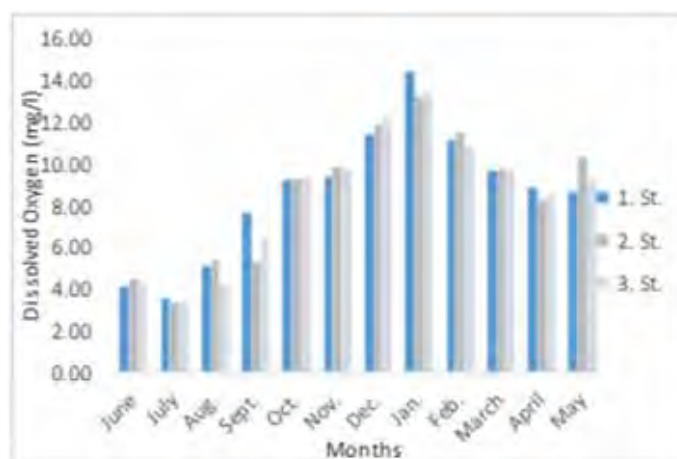


FIGURE 4

Mean amount of dissolved oxygen in upper Akcay River (mg/l)

seen July at station 3 ( $3.36 \text{ mg L}^{-1}$ ), whereas the maximum was  $14.45 \text{ mg L}^{-1}$  in January at station 1 (Table 2; Fig. 4).

Average dissolved oxygen values of all stations for monthly was  $8.56 \text{ mg L}^{-1}$ . Dissolved oxygen was found to be lower in the summer. When water temperature of the river decreased, dissolved oxygen levels increased suitable level. In summer, the river water used for irrigation activity and water

flow decreases. The amount of dissolved oxygen in the water depends on the water temperature, atmospheric pressure, mineral concentrations and water pollution level. The mean Dissolved oxygen is classified as class I to WPCR.

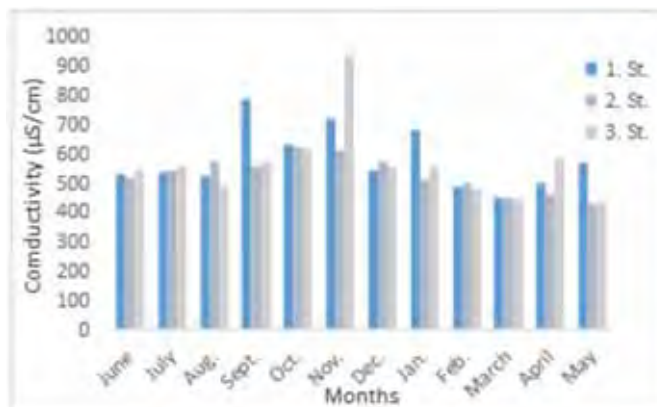
**Electrical conductivity.** Electric conductivity changes between  $430\text{-}936 \mu\text{S/cm}$ . The lowest value was  $430 \mu\text{S/cm}$  in May from station 2, the highest

value was 936  $\mu\text{S}/\text{cm}$  in November from station 3 (Fig. 5). The annual mean electrical conductivity value was 555.25  $\mu\text{S}/\text{cm}$ .

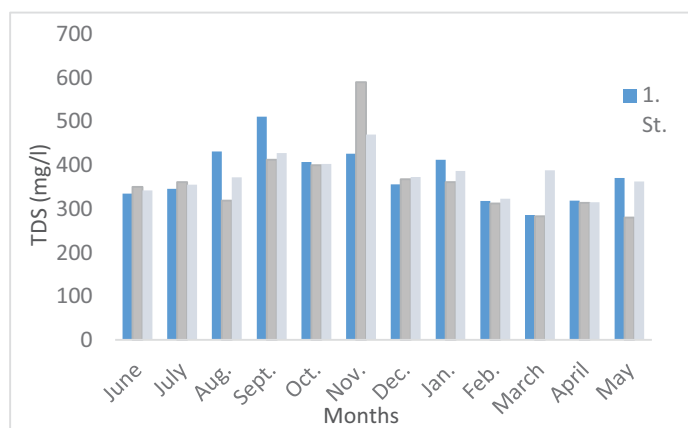
**Total Dissolved Solids (TDS).** TDS of upper Akcay River was measured as the lowest 280 mg/l in May and again as the highest 590 mg/l in November at 2. Station (Table 2). The mean Total Dissolved Solids values follow: station 1, 375.25

mg/L; station 2, 362.50 mg/L; station 3, 376.58. The mean value of all stations was 371.44 mg/l (Fig. 6).

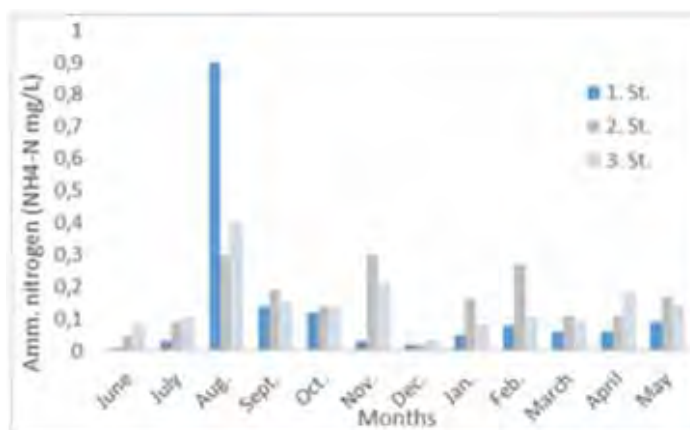
Water quality in terms of TDS values in upper Akcay River was II. class. Klein (1992) has reported that the excess amount of TDS in water disturbed ecological balance and cause distribution of aquatic biota.



**FIGURE 5**  
Electrical conductivity ( $\mu\text{S}/\text{cm}$ ) according to stations in upper Akcay River



**FIGURE 6**  
TDS (mg/L) value in upper Akcay River



**FIGURE 7**  
Ammonium nitrogen (mg/L) in upper Akcay River

**Ammonium nitrogen (NH<sub>4</sub>-N mg/L).** Ammonia nitrogen values varies between 0.01 and 0.40 mg/L. The mean ammonia nitrogen values follow: Station 1, 0.05 mg/L; station 2, 0.11 mg/L; station 3, 0.12 mg/L (Fig. 7).

Annual mean ammonium value was 0.09 mg/L. According to Anonymous (2015), this is classified as class II (Table 1).

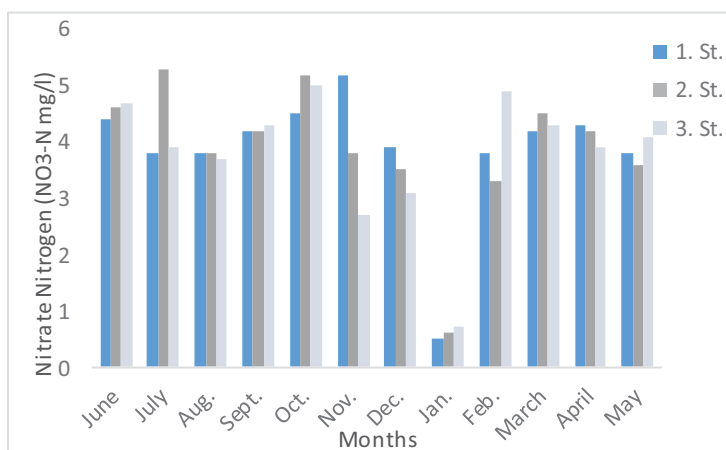
**Nitrate nitrogen (NO<sub>3</sub>-N mg/L).** Changes in nitrate nitrogen from all stations were found between 0.5-5.3 mg/L. The average nitrate nitrogen concentrations were 3.86 mg L<sup>-1</sup> for station 1; 3.88 mg L<sup>-1</sup> for station 2; 3.78 mg L<sup>-1</sup>. The mean nitrate in all stations is 3.84 mg L<sup>-1</sup> (Fig. 8). According to Anonymous (2015), this is classified as class I (Table 1).

The nitrite (NO<sub>2</sub>-N mg/L) level of River was close to zero. No significant difference in nitrate and nitrite levels throughout the year.

**Orthophosphate (PO<sub>4</sub>-P mg/L).** Orthophosphate phosphorus (PO<sub>4</sub>-P) change between 0.01-0.30 mg/L. Average values from stations were; 0.06 in station 1; 0.03 mg/L in station 2 and 0.05 mg/L in station 3. The mean annual value of orthophosphate was 0,04 mg/L (Fig. 9). According to Anonymous (2015), this is classified as class II (Table 1).

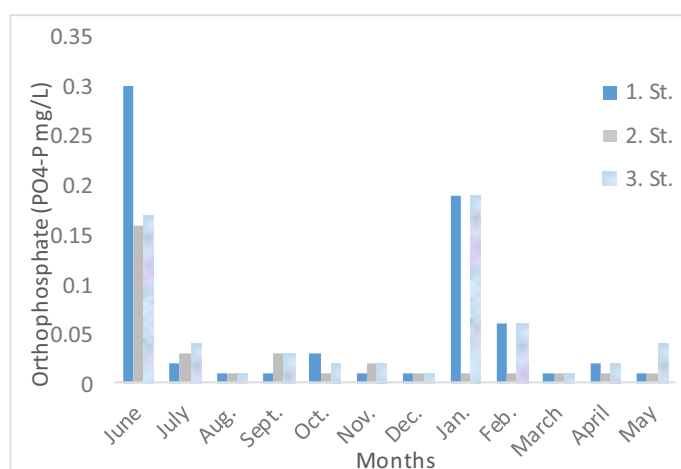
**Statistical analysis.** According to the Spearman's rho test, negative correlation was observed between the temperature values and dissolved oxygen values; also between TDS and annual pH levels. In addition, there was a positive correlation between the water temperature values and pH, electrical conductivity, orthophosphate.

There was no significant relationship between pH and electrical conductivity values or between nitrate and orthophosphate values but here was a positive correlation between nitrate and orthophosphate.



**FIGURE 8**

**Nitrate nitrogen values to stations in upper Akcay River (mg/L)**



**FIGURE 9**

**Orthophosphate phosphorus in upper Akcay River according to stations (mg/L)**

**TABLE 3**  
**Availability of the economic fish species in Upper Akcay River (Station 1, 2 and 3)**

Economic Fish species	Status of Fishes	Catchment Percentage (%)	Occurrence in Stations
<i>Onchorynchus mykiss</i>	Translocated	0.30	2, 3
<i>Capoeta bergamae</i>	Endemic-NT	12.08	1, 2, 3
<i>Alburnus escherichii</i>	Native	10.58	2, 3
<i>Vimba mirabilis</i>	Native-VU	25.38	1, 2, 3
<i>Chondrostoma meandrense</i>	Endemic-VU	11.78	1, 2, 3
<i>Squalius fellowesii</i>	Endemic-VU	34.75	1, 2, 3
<i>Barbus pectoralis</i>	Native	4.83	2, 3
<i>Carassius gibelio</i>	Exotic	0.30	3

**TABLE 4**  
**The fisheries activities in the Upper Akcay River**

Economic Fish species	Local name	Fishery activity	Locality	Yield (Kg) (x1000)
<i>Onchorynchus mykiss</i>	Alabalık	Aquaculture	Kemer D. Yemisendere	4584 9
<i>Capoeta bergamae</i>	Siraz			2
<i>Alburnus escherichii</i>	Cay balığı			1
<i>Vimba mirabilis</i>	Ulubat balığı			2
<i>Chondrostoma meandrense</i>	Kababurun	Fishing rods, scope nets	Upper Akcay	1.1
<i>Squalius fellowesii</i>	Tatlısu kefalı	and cast nets	River	1.5
<i>Barbus pectoralis</i>	Biyikli balık			1.2
<i>Carassius gibelio</i>	Gumusi Sazan			0.2
<i>Silurus glanis</i>	Yayın			0.5

**Distribution of Economic Fish and Fisheries.** The economic species caught in the river during a year survey included as *Onchorynchus mykiss*, *Capoeta bergamae*, *Alburnus escherichii*, *Vimba mirabilis*, *Chondrostoma meandrense*, *Squalius fellowesii*, *Barbus pectoralis* and *Carassius gibelio*. *C. gibelio*, an exotic fish and *O. mykiss*, an introduced fish of stations were the least caught, and *V. mirabilis* and *S. fellowesii*, endemic and native fish, were the most dominant species in upper Akcay River (Table 3).

According to the data obtained during the research in the region; A small trout farm is occur in the 2<sup>nd</sup> station on the Akcay River (Yemisendere) with 9 ton, while the aquaculture produces 5 trout farms in Kemer Dam with 4584 ton. The most common fish catchment for fishery in upper Akcay River was *C. bergamae* and *S. fellowesii*. Yield production of fisheries is 10.5 ton (Table 4).

## DISCUSSION

Water quality is effected from natural processes. Also, there are anthropogenic impacts, such as man-induced point and non-point sources, xenobiotics and alteration of water quality due to water use and river engineering projects as irrigation, damming. Water quality monitoring refers to the acquisition of quantitative and representative information on the physical, chemical, and biological characteristics of a water body [31, 32].

The mean water temperature was 16.15 °C, according to WPCR (Table 1) the water characteristic was classified as class I. The water quality is suitable for Aquaculture and fish cultivation such as trout. Water temperature is an important climatic factor, it increases biological activities and effect oxygen saturation [15]. In this study, the temperatures of all stations and the reference station did not vary significantly ( $P > 0.05$ ).

The mean values of pH was ranged between 7.56 and 7.59. According to the values of pH was found to be fairly alkaline in upper Akcay River. The pH is the scale of intensity of acidity and alkalinity of water and measures the concentration of hydrogen ions. the biological processes and biochemical reactions effect pH [33]. Accepted water quality criteria indicate a pH of less than 5.5 units may be harmful to many species of fish [32]. The pH value of 6.5 to 9.0 units would be optimal for the protection of aquatic habitats [34].

According to the EPA [32], the mean values of pH in upper Akcay River were normal. when water pH level is high, ammonium and nitrogen compounds have adverse effects. The value of pH, indicates that growing of fish is appropriate [29]. The pH value in stations were not different ( $P < 0.05$ ).

The mean values of dissolved oxygen was ranged between 8.47 mg/l and 8.63 mg/l in upper Akcay River. Dissolved oxygen is one of the most important parameter for water quality, because it shows the biological and physical processes prevailing in water. In freshwater ecosystems, the



minimum dissolved oxygen may not be less than 5.0 mg/l [35]. The values of dissolved oxygen were normal in upper Akcay River for aquatic life. According to classification continental inland water sources of Water Pollution Control Regulation in River was found I (Table 1). For trout cultivation and fishes, amount dissolved oxygen need to be higher than 5.00 mg L<sup>-1</sup> [34]. The mean dissolved oxygen in water is 8.56 mg L<sup>-1</sup>. Dissolved oxygen is classified as class I for the WPCR. In station III, the minimum dissolved oxygen value is 3.36 mg L<sup>-1</sup> in early summer, because it is highly use for irrigation and solid pollution from village.

The mean electrical conductivity value obtained in this study was 555.25 µS/cm. The conductivity value was observed in stations was no significantly different (Table 2). Conductivity level increased in accordance to water temperature and in total dissolved solids. Electrical conductivity of ions in water changed with the total concentration and depends on the change of temperature [36]. Decrease in electrical conductivity, means a reduction of total dissolved solids content [35].

The mean ammonium nitrogen values to stations changed between 0.05 (I. station) to 0.12 mg L<sup>-1</sup> (III. station) and the values obtained in the stations are no significantly different. Ammonium should be less than 1 mg/l in clean water [34]. NH<sub>4</sub>-N, which is the waste material of aquatic organisms, may be absorbed by organisms. Non-toxic ammonium depending on temperature and high pH (>8,5) could transform into ammonia and become toxic for fish and other aquatic biota [37]. According to Anonim WPCR of the value it is considered to be classified as level II [30].

The nitrite was below 0.001 mg/l all stations in upper Akcay river. According to classification continental inland water sources of the WPCR in river water is I (Table 1). The nitrite nitrogen of the water samples is an intermediate product of biological oxidation of ammonium to nitrate. The concentration of nitrite in natural lake water is generally low [35].

The mean value nitrate was ranged between 3.78 mg/l and 3.88 mg/l in upper Akcay River. The Nitrate nitrogen (NO<sub>3</sub>-N), the minimum nitrate

nitrogen concentration was 0.50 mg/L in January at station I, while the maximum value was 5.30 L<sup>-1</sup> in July at station II. Because of the waste product coming from farming and organic agricultural. Pollution can effect some variable characteristics regarding ammonium and nitrate in reservoirs and rivers [35]. According to WPCR, the average annual value of nitrate was about 3.84 mg/L, with this value in the River it could be categorized as I. class.

Dissolved organic phosphorus or suspended organic phosphorus found in natural water and the total phosphorus content in Akcay River was between 0.01-0.30 mg/L. The main source of phosphate is ortho-phosphate. The mean value of ortho-phosphate phosphorus (PO<sub>4</sub>-P) at stations in upper Akcay River was determined to be 0.04 mg/L. The highest orthophosphate value was seen in station I around 0.30 mg/L in June. In terms of orthophosphate phosphorus in upper Akcay River is classified to be level II [30].

According to WPCR, water containing 0.02 mg/L total phosphorus is classified to be at level I and is suitable for fish and fisheries. Phosphorus levels higher than 0.30 mg/L are considered as signal of pollution. The total phosphorus concentration in natural waters depends on the morphometry of basin, the chemical content of the region, and the existence of organic substances and organic metabolism in the water [34]. The orthophosphate concentrations at stations did not differ significantly (P<0.05).

In Upper Akcay River, the water quality parameters were compared with other studies reports. There are intensive fish aquaculture activities in Southwestern part of Turkey such as Esen River, Yuvarlakcay River, Bereket Dam Lake (Table 5). Bafa lake is a lagoon lake and many marine fish breeding activities. The inland water resources in southwestern part of Anatolia are suitable for culturing trout and fisheries. The concentrations of nitrite nitrogen, nitrate nitrogen, and orthophosphate reported for other freshwaters were not significantly different than our result in this study. Bereket Dam Lake's the nitrate and the phosphate values were higher because of intensive aquaculture activities (Table 5).

**TABLE 5**  
**Water physico-chemical values from other studies accomplished in upper Akcay River**

Locality (References)	T (°C)	Salinity (‰)	pH	EC (µS/cm)	DO (mg/l)	NO <sub>2</sub> -N (mg/l)	NO <sub>3</sub> -N (mg/l)	PO <sub>4</sub> -P (mg/l)
Yuvarlakcay [10]	19.3		8.1	400	8.50	0.01	0.23	0.001
Aglasun Deresi [38]	13.03		7.40	484	8.33		5.80	0.39
Hasan River [39]	15.72	0.15	8.51		9.48		2.3	0.001
Bereket D. Lake [40]	15.42	-	7.93	0.71	6.76	1.17	6.45	0.91
Gazibey D. Lake [41]	13.85		8.1	798	9.9	0.002	0.30	0.014
Aksu River [42]	20.49		8.38	714.53	6.27	0.20	2.75	0.52
Bafa Lake [43]	22.21	12.95	8.26	2088	7.52	0.04	2.10	0.19
Esen River [44]	14.74		7.7	357.71	8.32	0.003	3.33	0.075
Akcay River	16.15	0.25	7.58	555.25	8.56	0.01	3.84	0.30

Many threats of freshwater biota underline about many changes in habitat or community structure, such as pollution, flow regulation, loss or change of aquatic habitat, over-exploitation and introduction of exotic species. These reasons have all contributed through the critical situation facing many freshwater fish species in South-western Anatolia as *Vimba mirabilis* and *Chondrostoma meandrense*. *Vimba mirabilis* is known by the original description from Buyuk Menderes and threatened due to water abstraction. This species extinct from Bafa Lake which connection was banned with Buyuk Menderes River artificial barrier [19]. The decline in fish species and around reservoir is the largest documented loss of biodiversity caused by humans and alien species in an ecosystem. *Carassius gibelio* are potential competitors for the food of numerous endemic and native fish species.

The Akcay River threatened mainly by draining of water as agricultural irrigation, prevention of natural water flows to wetlands by dam constructions, urban development on wetlands and surroundings (urban and industrial utilization), chemical contamination due to the industrial as tar, olive oil activities, household wastes, introduction of exotic species, unsustainable fishing and plants collecting. In the future, the establishment of a hydroelectric power plant on the upper Akcay river is discussed. This study is important because it contributes to the determination of the current situation.

## CONCLUSIONS

Recommendations with the result obtained on the analyses on water quality of the river can be sustained by the biota and habitat.

There is no deterioration in water quality in the stations in upper Akcay river. It has a unique and sensitive habitats as the Buyuk Menderes basin. Therefore, these areas should be protected and monitoring should be carried out.

There is no excessive fish farming in the upper Akcay River. Aquaculture activities is seems very intensive in Kemer Dam Lake to affect the entire dam lake. Clear definition of the receiving environment will facilitate implementation of legal and technical measures to sustain and preserve development. Agricultural activities and domestic wastes should be checked and removed so as not to cause pollution.

The river should be protected from the richness and evenness of riparian vegetation.

The variety of native Fish should be protected. Native and endemic species such as *Vimba mirabilis* and *Chondrostoma meandrense* should be preserved. Exotic species such as *Carassius gibelio* damaged the environment.

It must be a strict implementation of the policies endemic species. illegal fishing should be controlled. The river should be protected from exotic vegetation and fauna.

It should be a community-based management of river by monitoring the area regularly.

These are recommended in order for the quality of the stream and could be preserved for the next generation to see and experience the richness of upper Akcay River.

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