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Research Article

Investigation of Seasonal Effects of Trout Farms on Water Quality in Nigde Province

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Abstract

In this research, the water quality parameters of Nigde province trout fish farms were examined. In this study, physico-chemical analysis (temperature, dissolved oxygen, chemical oxygen demand, nitrite and nitrate) were conducted seasonally in the entering and exodus of pools at farms. It was concluded from this study, that mean values of the temperature in place of all farms in all seasons were 12.78 ^{o}C and 13.02 ^{o}C at the pool entering and pool exodus, respectively. Dissolved oxygen (O_2) average levels were found as 9.17 and 8.69 mg/l in the pool entering and pool exodus, respectively, while the average chemical oxygen demand (COD) levels were 22.08 and 25.95 mg/l. The average nitrite (NO_2) levels for all farms in all seasons were 0.019 and 0.021 mg/l at the pool entrance and pool exit, whereas the nitrate (NO_3) values were confirmed as 0.217 and 0.248 mg/l, respectively. The results of this study show that the water source used for aquaculture in these farms is suitable for trout farming and the water at the pond outlets is at an acceptable level in terms of water quality parameters.

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NİĞDE İLİNDE ALABALIK ÇİFTLİKLERİNİN SU KALİTESİ ÜZERİNE DÖNEMSEL ETKİLERİNİN ARAŞTIRILMASI

Özet

Bu araştırmada, Niğde ili alabalık çiftliklerinin su kalitesi parametreleri incelenmiştir. Bu çalışmada, çiftliklerdeki havuzların giriş ve çıkışlarında mevsimsel olarak fiziko-kimyasal analizler (sıcaklık, çözünmüş oksijen, kimyasal oksijen ihtiyacı, nitrit ve nitrat) yapılmıştır. Bu çalışmada, tüm mevsimlerde tüm çiftliklerin yerindeki ortalama sıcaklık değerlerinin havuza girişte ve havuz çıkışında sırasıyla 12.78 ^{o}C ve 13.02 ^{o}C olduğu sonucuna varılmıştır. Havuza girişte ve havuz çıkışında çözünmüş oksijen (O_2) ortalama seviyeleri sırasıyla 9.17 ve 8.69 mg/l, ortalama kimyasal oksijen ihtiyacı (KOİ) 22.08 ve 25.95 mg/l olarak bulunmuştur. Tüm mevsimlerde tüm çiftlikler için ortalama nitrit (NO_2) seviyeleri havuz girişinde ve havuz çıkışında 0.019 ve 0.021 mg/l iken, nitrat (NO_3) değerleri sırasıyla 0.217 ve 0.248 mg/l olarak belirlenmiştir. Bu çalışmanın sonuçları, bu çiftliklerde yetiştiricilik için kullanılan su kaynağının alabalık yetiştiriciliği için uygun olduğu ve havuz çıkışlarındaki suyunda su kalitesi parametreleri bakımından kabul edilebilir düzeyde olduğu görülmüştür.

Anahtar Kelimeler
Su Kalitesi
Alabalık Çiftlikleri
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1. INTRODUCTION

Fishing from natural resources going to be limited, but due to increasing world population, fish obtained from aquaculture gradually becoming a main source of protein for human food intake in the nearby future [1,2]. Aquaculture is an emergent and rising sector in whole world. It was reported by food and agricultural organization, that Türkiye is the third strongest aquaculture developing country all over the globe [3] and whole Worldwide production of aquaculture is 170 million tons [4]. In Türkiye Fish production, was specifically started in the 1970s, which was approximately 630 thousand tons in total, from which 354 thousand tons were obtained by hunting and 276 thousand tons were obtained from aquaculture. In Türkiye trout fish positions first by producing about 120 thousand tons per year, amongst other fish species that are cultured [5]. It is because of easy and high amount of production of trout fish in farming as compared to other fish species, the well marketable, and enough availability of fresh water reservoires with appropriate features for aquaculture in Türkiye [6]. In recent years constant escalation in production level of aquaculture to meet the requirements of growing population, contamination of water reservoires is increasing [7]. Additionally, infact global warming is causing destruction of natural stocks, so attention towards aquaculture is augmented [8]. The production of cultured fish species has improved globally in previous years, mostly due to overfishing and the requirement for new food supplies [9].

With the growing demand for fish all over the world [2], industry of aquaculture could not exploring new approach to yield more fish devoid of any concomitant ecological destruction [10,11,12]. Water is a main requirement for aquaculturing, so aquaculture corporate should be properly prepared in terms of quality and quantity of water. According to fish culturists experts “the success or failure of any fish cultural process is totally determined by the Water quality" [13].

There are two foremost types of water supplies for aquaculture, one is groundwater and other is surface water. Groundwater is normally known as the utmost desired water source for aquaculture, due to its certain location, it is generally stable in quantity and quality of water, without any toxic impurity. Groundwater (spring water) has constant and appropriate temperature characteristics even in different seasons, therefore springs are the best water source for salmon and trout culture. Activities in fish culturing produces wastes from uneaten feed and fish feces and it can also pollute the outlet source of water if discharged without any cleaning treatment [14,15,16,17,18,19]. Generally two types of changes occur in the quality of water includes modifications in the surface of the water ecologies and modifications in the sediment of water ecologies [20,21,22,23]. There are different parameters of aquaculture farming which can pollute the ecosystem comprising nutrients, surplus feed and feces, chemical residues like nitrogen and phosphorus and microbial capacity [24,25,26,27,28]. These parameters can change according to different seasons, sites and managing teams of aquaculture [29]. The aim of this study was to examine the water quality parameters of some trout farms in the Nigde province. For this purpose, temperature, dissolved oxygen, COD, nitrite and nitrate were evaluated seasonally (spring, summer, autumn, winter) from determined stations (farm entrance and farm exit) in trout farms.

2. MATERIAL AND METHODS

In this research study, physico-chemical analyzes were done of water samples obtained from the pool entering and pool exodus in all four seasonal periods (spring, autumn, summer, winter) for determining the water quality in four trout farms of Nigde province. For each trout farm, measurements were made at two stations as pool entrance (station I) and pool exit (station II). The location of the field where the research was conducted is shown in Figure 1.

Some information about the production capacities of the examined trout facilities is summarized in Table 1.

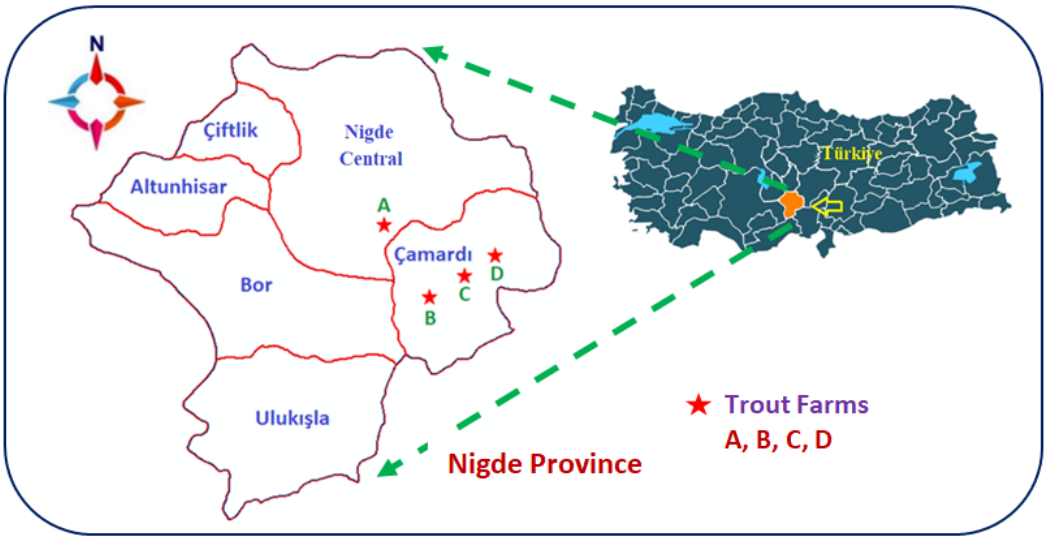

Figure 1. The Location of Research Area

Table 1. Production capacities and some technical characteristics of trout farms

Trout Farms	Production Method	Farms Type	Project Capacity (kg)	Species
A	Soil Pool	Hatchery+ Grower	20.000	Rainbow trout
B	Soil Pool	Hatchery+ Grower	29.000	Rainbow trout
C	Concrete Pool	Hatchery+ Grower	29.000	Rainbow trout
D	Concrete Pool	Hatchery+ Grower	17.000	Rainbow trout

Water temperature, dissolved oxygen (DO), chemical oxygen demand (COD), nitrite (NO_2) and nitrate (NO_3) were taken periodically from the water sources of four trout farms in the research area. Looking at the studies in the literature; It has been observed that the above-mentioned criteria are taken into account in determining the water quality for general trout farming. Temperature and dissolved oxygen were found by using a portable multi-parameter measuring device and on-site probe systems.

The water samples were taken into 0.5 ml plastic bottles and brought to Nigde Ömer Halisdemir University, Faculty of Agricultural Sciences and Technologies, Department of Animal Production and Technologies Research Laboratory within a few hours and kept at 4°C. In the water samples, Nitrite Nitrogen (NO_2-N mg/l) (using kit No. Merck 14776), Nitrate nitrogen (NO_3-N mg/l) (Using kit No. Merck 09713) and COD were measured in a spectrophotometer (Using Ready Kit: LCI500, Hach Lange). The results were evaluated by considering the Quality Criteria of Inland Water Resources by Class [30].

3. RESULTS AND DISCUSSION

The periodic variation of the water temperature in the A, B, C and D farms are presented in Table 2. The water temperature of the pool entering and pool exodus of farm A were 14.20°C and 14.40°C in spring season. In the summer season, the temperature was 15.20°C and 15.60°C in the pool entering and pool exodus, respectively. Temperature value of autumn season was determined as 12.60°C in the pool entrance, while this value was 12.70°C in the pool exit. In winter season temperature was found as 10.00°C in the pool entering and 10.20°C in the pool exodus. The average temperature value of farm A was determined as 13.11°C. Regression analysis between the measured temperature values, the R2 value was determined to be 0.6811 and it was concluded that there was a significant 68% relationship

between the values. In the farm B the water temperature of the pool entering was 14.10°C, while it was determined as 14.35°C in the pool exodus in spring season.

Table 2. Temperature (T) changes of trout farms

T (°C)					
		Trout Farms			
Seasons		**A**	**B**	**C**	**D**
Spring	Entrance	14.20	14.10	13.20	12.90
	Exit	14.40	14.35	13.60	13.10
Summer	Entrance	15.20	15.40	16.20	15.20
	Exit	15.60	15.90	16.40	15.64
Autumn	Entrance	12.60	12.30	12.10	12.50
	Exit	12.70	12.50	12.25	12.80
Winter	Entrance	10.00	9.08	9.80	9.75
	Exit	10.20	9.19	9.89	9.86
Average		13.11	12.85	12.93	12.72
Standard deviation		2.138	2.609	2.491	2.135
R^2		0.6811	0.6660	0.4660	0.4364

In summer, the temperature was found as 15.40°C in the entering of the pool and 15.90°C in the exodus of the pool. In autumn season, the temperature values of the pool entering and pool exodus were 12.30°C and 12.50°C, respectively. The temperature of the farm B in winter season was found as 9.08°C and 9.19°C in the pool entering and pool exodus, respectively. The average temperature value of farm B was determined as 12.85°C. Regression analysis between the measured temperature values, it was determined that the R^2 value was 0.6660 and it was concluded that there was a significant 66% relationship between the values. The description of farm C water temperature in different seasons also given in Table 1. The temperature value of pool entering and pool exodus in spring season was determined as 13.20°C and 13.60°C, respectively, while the temperature measured from the same pool entering and pool exodus in winter season were 9.80°C and 9.89°C, respectively. The summer period water temperature was found as 16.20°C in the entering of pool and 16.40°C in the exodus of pool. In the autumn season water temperature was found as 12.10°C in the entrance of pool and 12.25°C in the exit of pool. Regression analysis between the measured temperature values, it was determined that the R^2 value was 0.4660 and it was concluded that there was no significant relationship between the measured values. The seasonal temperature distribution of the water in farm D is also given in Table 2. The pool entering and exodus temperature values in spring season in farm D were found to be 12.90°C and 13.10°C respectively, while these values became 15.20°C and 15.64°C, respectively in summer season. The pool entrance temperature in winter was found as 9.75°C, while this value was calculated as 9.86°C in the pool exodus. The pool entering water temperature in autumn season was 12.50°C, while the pool exodus water temperature was found as 12.80°C.

The highest temperature was observed in summer as 15.64°C. Regression analysis made between the temperature values measured in farm D, it was determined that the R^2 value was 0.4364 and it was concluded that there was no significant relationship between the values. According to previos studies the comparison of water temperature did not gave any substantial variances between inlets and outlets pools of fish farms were observed for [29], indicating that the examined fish farms influencing no effect on downstream river quality. According to discharge certificate specified that the emitting water temperature had to be ‘‘ambient’’ and no significant changes were found between inlets and outlets pools of fish farms showing that the emitting water was really at ambient temperature [29]. In another

study, scientists did not detect some influence of trout fish farms on the temperature of receiving water [31]. Influence of different seasons was but in a specific range, except slight upturn (2.6%) during the spring season [32]. Another study found no significant temperature changes between inlets and outlets pools of fish farms even the temperature of outlet pools remained in the predictable range (11.6 -14.3 °C) for all season of the year [33]. The changes in the dissolved oxygen (O_2, mg/l) values in the entering and exodus of the pool in the trout farms were investigated throughout four seasons. The seasonal variation in the amount of dissolved oxygen in farm A, B, C, D are shown in Table 3. Dissolved oxygen values of spring season in farm A were determined as 9.88 and 9.03 mg/l in the entering and exodus of the pool, respectively, while this value was found as 8.58 and 8.02 mg/l in summer season. In the autumn season, values of pool entering and pool exodus of the same farm were found as 7.96 and 7.15 mg/l, respectively. Dissolved oxygen values in the winter season were 8.36 mg/l and 8.18 mg/l in the pool entrance and pool exit, respectively. Regression analysis of these dissolved oxygen values, the R^2 value was 0.5004 and it was concluded that there was no significant relationship between the values. The seasonal variation of the dissolved oxygen values of farm B is also given in Table

Table 3. Dissolved oxygen (O_2) changes of trout farms

O_2 (mg/l)					
		Trout Farms			
Seasons		**A**	**B**	**C**	**D**
Spring	Entrance	9.88	10.25	10.42	9.56
	Exit	9.03	9.36	10.07	9.14
Summer	Entrance	8.58	9.87	9.74	10.07
	Exit	8.02	9.48	9.46	9.74
Autumn	Entrance	7.96	8.27	8.75	8.75
	Exit	7.15	7.68	8.24	8.39
Winter	Entrance	8.36	8.97	9.03	8.21
	Exit	8.18	8.25	8.73	8.08
Average		8.40	9.02	9.31	8.99
Standard deviation		0.808	0.888	0.745	0.749
R^2		0.5004	0.6077	0.7568	0.6704

The dissolved oxygen values of spring season at the pool entering were 10.25 mg/l while 9.36 mg/l at the pool exodus. In summer season, dissolved oxygen values were found as 9.87 mg/l in the pool entering and 9.48 mg/l in the pool exodus. However, in autumn season, dissolved oxygen value of the pool entering was 8.27 mg/l, while it was found as .68 mg/l in the pool exodus. In winter season, this value was determined as 8.97 mg/l and 8.25 mg/l in the pool entering and pool exodus, respectively. The average dissolved oxygen value of farm B was determined as 9.02 mg/l. Regression analysis between the measured dissolved oxygen values, it was determined that the R^2 value was 0.6077 and it was concluded that there was no significant relationship between the values. Dissolved oxygen values of the pool entering and pool exodus in farm C in spring season were 10.42 mg/l and 10.07 mg/l respectively, whereas this value was measured as 9.03 mg/l and 8.73 mg/l, respectively in winter season. In the autumn season dissolved oxygen values were found as 8.75 and 8.24 mg/l, respectively in the pool entering and pool exodus. Regression analysis made between the measured dissolved oxygen values, it was determined that the R^2 value was 0.7568 and it was concluded that there was a significant relationship between the values at the rate of 76%. The seasonal variation in the values of dissolved oxygen in farm D is presented in Table 2. Dissolved oxygen value in the pool entering and pool exodus of farm D were found as 9.56 and 9.14 mg/l, respectively in

spring season and this value increased to 10.07 and 9.74 mg/l, respectively in summer season. Winter season dissolved oxygen values of the pool entering and exodus were measured as 8.21 mg/l and 8.08 mg/l, respectively. In autumn season these values were found as 8.75 mg/l and 8.39 mg/l. Regression analysis made between the measured dissolved oxygen values, it was determined that the R^2 value was 0.6704 and it was concluded that there was no significant relationship. According to previous studies dissolved oxygen can be vary between inlet and outlet pools of fish farms as in one study significant reduction was found at outlet pool of fish farms as compared to inlets pool [29] probably, due to consumption of oxygen during metabolism of fish [34]. A typical decrease in dissolve oxygen of approximately 1.42 mg O_2/l was found from inlets and outlets pools of fish farms [29], that was also found in other study where dissolve oxygen reduced to 0.7 - 2.4 mg O_2/l according to investigated fish farm [35]. Some studies proven that the influence of trout fish farms on outlet pools of water quality was greater in summer seasons when quantity of fish is high, and both dissolve oxygen and river flow are less [34]. In another study significant reduction of dissolve oxygen (5.3%) was observed maybe due to fast metabolism of fish and decay of living material [32, 36]. According to mean values of dissolve oxygen significantly less quantity of dissolve oxygen was observed at outlet pool of fish farm as compared to inlet pool in all seasons [33]. Seasonal variations in chemical oxygen demand (COD, mg/l) values of pool entering and pool exodus of farms were presented in Table 4.

Table 4. Changes of chemical oxygen demand (COD) in trout farms

COD (mg/l)					
		Trout Farms			
Seasons		**A**	**B**	**C**	**D**
Spring	Entrance	18.30	19.32	17.36	29.47
	Exit	22.13	23.87	21.58	33.61
Summer	Entrance	28.47	25.37	22.98	25.41
	Exit	35.89	31.71	25.69	26.39
Autumn	Entrance	25.36	23.02	19.79	21.07
	Exit	31.08	29.68	24.19	25.63
Winter	Entrance	19.67	17.37	18.37	21.87
	Exit	21.59	19.18	20.47	22.58
Average		25.31	23.69	21.30	25.75
Standard deviation		6.096	5.111	2.869	4.195
R^2		0.0015	0.0278	0.0012	0.6018

The COD values of the pool entering and exodus in farm A were found as 18.30 and 22.13 mg/l, respectively in spring season, while these values were found as 28.47 and 35.89 mg/l, respectively in summer season. COD values were determined as 25.36 and 31.08 mg/l in the pool entering and pool exodus in the autumn season, whereas this value was decreased to 19.67 mg/l and 21.59 mg/l in the entering and exodus of the pool, respectively in the winter season. The mean COD change was determined as 25.31 mg/l. Regression analysis between the measured COD values, the R2 value was determined to be 0.002 and it was concluded that there was no significant relationship between the values. The COD values of the pool entering and pool exodus of the farm B were found as 19.32 mg/l and 23.87 mg/l, respectively in spring season. In summer season, the COD values were determined as 25.37 mg/l and 31.71 mg/l in the pool entering and exodus, respectively. This value was observed lower in autumn season as 23.02 mg/l and 29.68 mg/l. However, in winter season, COD values of pool entering and exodus were determined as 17.37 mg/l and 19.18, respectively. The average COD value of farm B was determined as 23.69 mg/l.

Regression analysis made between the COD values measured in farm B, the R^2 value was determined to be 0.0278 and it was concluded that there was no significant relationship between the values. The COD value in the farm C were found as 17.36 and 21.58 mg/l in the pool entering and pool exodus, respectively in spring season, while this value was observed as 18.37 and 20.47 mg/l in winter season. The COD values were measured as 22.98 and 25.69 mg/l in the entering and exodus of the pool in summer season. The COD values of the entering and exodus of the pool in autumn were 19.79 and 24.19 mg/l, respectively. The average COD value on the basis of all seasons in farm C was found to be 21.30 mg/l. Regression analysis between the measured COD values, the R^2 value was determined to be 0.0012 and it was concluded that there was no significant relationship between the values.

In the farm C, COD values of the spring season were found as 29.47 and 33.61 mg/l in the entering and exodus of the pool, respectively, while it decreased to 25.41 and 26.39 mg/l in summer season. The lowest COD values were measured as 21.07 mg/l and 25.63 mg/l at the entering and exodus of the pool in autumn season. In the winter season COD values of the pool entering and exodus were measured as 21.87 mg/l and 22.58 mg/l, respectively. The average COD value of farm D was found to be 25.75 mg/l. Regression analysis between the measured COD values, it was determined that the R^2 value was 0.6018 and it was concluded that there was no significant relationship between the values. An inverse relationship was observed in previous studies between concentration of dissolved oxygen and temperature, such as oxygen reduction was more evident throughout the warmest season. About 15°C temperature could increase food feeding of cultured fish and consequently an upsurge in their metabolism and respiration level, so it leads to significant reduction in the dissolved oxygen of fish farms. Besides this, chemical oxygen demand was amplified by 67.5%, possibly due to increases in dead organic matter due to deficiency of oxygen [37]. The nitrite values (NO_2) (mg/l) changes in farm A, B, C and D are shown in the Table 5.

Table 5. NO_2 changes of trout farms

NO_2 (mg/l)					
		Trout Farms			
Seasons		**A**	**B**	**C**	**D**
Spring	Entrance	0.025	0.049	0.032	0.032
	Exit	0.029	0.054	0.041	0.037
Summer	Entrance	0.015	0.016	0.016	0.017
	Exit	0.016	0.017	0.017	0.019
Autumn	Entrance	0.011	0.012	0.012	0.013
	Exit	0.013	0.014	0.014	0.016
Winter	Entrance	0.010	0.015	0.011	0.012
	Exit	0.012	0.016	0.014	0.015
Average		0.016	0.024	0.020	0.020
Standard deviation		0.007	0.017	0.011	0.009
R^2		0.6878	0.5575	0.5937	0.6339

The NO_2 values at the entering and exodus of the pool in farm A were 0.025 and 0.029 mg/l, respectively, in spring season, while these values were determined as 0.015 and 0.016 mg/l in summer season. The values determined in autumn season in the pool entering and exodus were found to be 0.011 and 0.013 mg/l, respectively. Nitrite values in winter season were reported as 0.010 mg/l in the pool entering and 0.012 mg/l in the pool exodus. Average NO_2 change was determined as 0.016 mg/l in the farm A. Regression analysis made between the measured NO_2 values, it was determined that the R^2 value was 0.6878 and it was concluded that there was a partially significant relationship between the values.

The seasonal changes of NO_2 (mg/l) values of the water samples in farm B were found as 0.049 mg/l at the pool entering and 0.054 mg/l at the pool exodus in spring season. In summer season, this value was determined as 0.016 mg/l in the pool entering and 0.017 mg/l in the pool exodus, while values were found lower in the autumn season (0.012 mg/l and 0.014 mg/l, respectively). In winter season, the value of the pool entering was 0.015 mg/l and it increased to 0.016 in the pool exodus. The average NO_2 value of farm B was determined as 0.024 mg/l. Regression analysis made between the NO_2 values measured in farm B, the R^2 value was found to be 0.5575 and it was concluded that there was no significant relationship between the values. The seasonal variation of Nitrite (NO_2) (mg/l) values in of the pool entering and pool exodus in the farm C is also given in Table 5. The NO_2 values of the the pool entering and exodus in farm C were found to be 0.032 and 0.037 mg/l, respectively in spring season. In winter season this value was measured as 0.011 mg/l and 0.014 mg/l in the pool entering and pool exodus, respectively. Nitrite values of summer season in the entering and exodus of the pool were reported as 0.016 and 0.017 mg/l, respectively. However, these values were found lower (0.012 and 0.014 mg/l) in the autumn season. The average NO_2 value was found to be 0.020 mg/l in the farm C. Regression analysis made between the measured NO_2 values, it was determined that the R^2 value was 0.5937 and it was concluded that there was no significant relationship between the values. The Nitrite values at the pool entering and exodus of the farm D was 0.032 and 0.037 mg/l, respectively in spring season and it decreased to 0.017 and 0.019 mg/l, respectively in summer season. These values were measured as 0.013 mg/l and 0.016 mg/l in the entering and exodus of the pool in autumn season, while these values were reported as 0.012 mg/l and 0.015 mg/l, respectively in winter season. The average NO_2 value of farm D was determined as 0.020 mg/l.

Regression analysis made between the measured NO_2 values, it was determined that the R^2 value was 0.6339 and it was concluded that there was a partially significant relationship between the values. A less concentration of NO_2-N was observed at the inlet pool of fish farm and thus beside the river [29]. Consequently, the activity of fish farm may be had a positive influence on the quality of river concerning the concentration of NO_2-N [29]. On the other side scientists found a significant increment of NO_2-N concentration from 0.019 to 0.581 mgN/L from upstream level to downstream level from five diverse trout farms [31]. While in some studies no major differences were found for NO_2 concentrations in the entering and exodus of pools of fish farms [32,35,38]. Seasonal changes in Nitrate (NO_3) values of the pool entering and exodus in trout farms were presented in Table 6.

Table 6. NO_3 changes of trout farms

NO_3 (mg/l)					
		Trout Farms			
Seasons		**A**	**B**	**C**	**D**
Spring	Entrance	0.200	0.180	0.190	0.210
	Exit	0.220	0.220	0.210	0.240
Summer	Entrance	0.280	0.260	0.240	0.290
	Exit	0.320	0.290	0.280	0.340
Autumn	Entrance	0.240	0.200	0.260	0.260
	Exit	0.260	0.250	0.290	0.290
Winter	Entrance	0.150	0.140	0.190	0.180
	Exit	0.190	0.160	0.200	0.210
Average		0.233	0.213	0.233	0.253
Standard deviation		0.054	0.052	0.041	0.053
R^2		0.0908	0.1368	0.0052	0.0440

The Nitrate values of the pool entering and exodus of the farm A were reported as 0.200 and 0.220 mg/l, respectively in spring season, while these values were determined higher as 0.280 and 0.320 mg/l in summer season. In the autumn season NO_3 values of the winter season were found to be 0.240 and 0.260 mg/l in the pool entering and exodus, respectively. Nitrate values in winter season were 0.150 mg/l at the pool entering and 0.190 mg/l at the pool exodus. The average NO_3 change was determined as 0.233 mg/l. Regression analysis made between the measured NO_3 values, it was determined that the R^2 value was 0.0908 and it was concluded that there was no significant relationship between the values. The seasonal changes in NO_3 values in farm B are also shown in Table 6. The nitrate values of the farm B was determined as 0.180 mg/l at the pool entering in spring season, while this value was found as 0.220 mg/l at the pool exodus. Nitrate values were higher as 0.260 mg/l at the pool entering and 0.290 mg/l at the pool exodus in summer season, whereas this value was measured as 0.200 mg/l at the pool entering and 0.250 mg/l at the pool exodus in autumn season. In winter season this value was 0.140 mg/l in the pool entering and it increased to 0.160 in the pool exodus. The average NO_3 value of the farm B was determined as 0.213 mg/l.

Regression analysis made between the NO_3 values measured in farm B, it was determined that the R^2 value was 0.1368 and it was concluded that there was no significant relationship between the values. In the farm C the NO_3 values of the pool entering and pool exodus were 0.190 mg/l and 0.210 mg/l, respectively in the spring season. Nitrate values of the entering and exodus of the pool in summer season were found to be 0.240 and 0.280 mg/l, respectively. These values at the entering and exodus of the pool in autumn season were found to be 0.260 and 0.290 mg/l, respectively. However, in the winter season NO_3 values were reported as 0.190 and 0.200 mg/l, in the entering and exodus respectively. The average NO_3 value was found to be 0.233 mg/l for all seasons in farm C. As a result of the regression analysis made between the measured NO_3 values, it was determined that the R^2 value was 0.0052 and it was concluded that there was no significant relationship between the values.

The Nitrate values at the pool entering and exodus of the farm D was determined as 0.210 and 0.240 mg/l respectively in spring season and it increased to 0.290 and 0.340 mg/l, respectively in summer season. In the autumn season, NO_3 values were measured as 0.260 mg/l and 0.290 mg/l at the entering and exodus of the pool, whereas these values were found lower (0.180 and 0.210 mg/l) in the winter season. The average NO_3 value was found to be 0.253 mg/l in farm D. Regression analysis made between the NO_3 values determined in farm D, the R^2 value was determined to be 0.044 and it was concluded that there was no significant relationship between the values. According to mean value calculation in previous studies no significant difference of nitrate NO_3 concenteration was observed between inlets and outlets pools of different trout fish farms [29].

In another study on freshwater salmonids fish farms in Canada nitrate (NO3) concenteration increase from 0.13 mgN/L to 0.43 mgN/L from upstream to downstream levels of water but no significant change was detected [16]. A significant influence of trout fish farming on quality of river in terms of nitrate (NO_3) concenteration was found by researchers [31]. In another study in France on possible effect of different trout fish farms confirmed that fish farms possibly will be also responsible of decrease or increase of NO_3 concentrations in the river water [2]. While some studies demonstrated no significant difference of NO_3 concnteration in the inlet and outlets pools of fish farms [32, 35, 38]. In the literature, there are many studies on trout farming and water quality in Türkiye. For example; In a study conducted to assess the water quality of Almus Dam Lake in terms of trout farming, the water quality of the research area was monitored for one year. It was determined that dissolved oxygen 8.2 - 11.2 mg/l, nitrite 0.005 - 0.016 mg/l and nitrate concentrations varied between 0.04 - 0.38 mg/l in the water samples taken. It was concluded from research tht the water quality of the Dam Lake was appropriate for trout farming [39].

A research was carried out to determine the suitability of the waters of Köroğlu Stream in Erzincan Refahiye district for fish farming. Some physical and chemical properties of water were determined in water samples taken on a seasonal basis for two years. It was determined that the COD value varied between 1.1 - 5.5 mg/l, NO_2 was 0.002 - 0.045 and NO_3 was 0.6 - 2.4 mg/l.

The findings were determined to be suitable for fish farming according to the Water Pollution Control Regulation Inland Water Resources Criteria, Drinking Water Quality Criteria (TSE 266, EC, WHO, EPA) [40]. The effects of fish farming on water quality were investigated in a study conducted in Ildır Bay (Izmir-Aegean Sea). For this purpose, seasonal water sampling was carried out from three stations established. As a result of the analyzes made in the water samples, it was determined that the dissolved oxygen varied between 5.2 - 9.2 mg/l, the nitrite nitrogen (below the measurement limit) 0.44 µgat/L, and the nitrate nitrogen 1.12 µgat/L [41]. As can be seen from the studies, it is seen that the water quality should be monitored in fish farming and the change in quality parameters adversely affect fish production.

In another study; The water quality of Özlüce Dam Lake was evaluated in terms of trout farming. For this purpose, monthly water samples were taken from 5 different points of Özlüce Dam Lake located within the provincial borders of Elazığ and Bingöl. pH, temperature, dissolved oxygen, nitrite and nitrate values were measured in the water samples taken. As a result of the research, it was concluded that the water quality of Özlüce Dam Lake is suitable for fish farming [42].

4. CONCLUSIONS

The physico-chemical parameters (temperature, dissolved oxygen, chemical oxygen demand, nitrite and nitrate) of trout frams were evaluated seasonally in this study. Results showed that the average temperature value (in all farms for all seasons) of the pool exodus was higher than the pool entering, while dissolved oxygen levels of pool exodus were lower than that of the pool entering.

The average chemical oxygen demand levels were determined as 22.08 mg/L at the pool entrance, whereas it was found higher as 22.95 mg/L at the pool exit in all farms for all seasons. Nitrite and nitrate levels were showed higher values at the pool entering than the pool exodus in all seasons for all farms.

According to the results of this research, it can be concluded that the water source of these farms is suitable for trout farming. After this study it is recommended that good water quality management in aquaculture is required for culturing good fish well-being and production. The sites for aquaculture reservoir should have favorable environment without any polluted contaminants. Additionally aquaculture site should be specified according to fish species which have to be cultured.

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5. REFERECES

[1] Donnely N. Potential diversification opportunities for the land-based aquaculture sector in Northern Ireland, European Union, 2011.
[2] Guilpart A, Roussel JnM, Aubin J, Caquet T, Marle M, Le Bris H. The use of benthic invertebrate community and water quality analyses to assess ecological consequences of fish farm effluents in rivers, *Ecological Indicators*, 2012; 23:356-365 Doi: 10.1016/j.ecolind.2012.04.019.
[3] Coşkun F, Gültek A, Patrona K, Gür A. Aquaculture Industry Report, 2011.
[4] TUIK. Fisheries Statistics, Turkish Statistical Institute, 2018, Ankara.
[5] TUIK. Fisheries Statistics, Turkish Statistical Institute, 2020, Ankara.
[6] Emre Y, Kürüm V. Trout Breeding, 2nd Edition, Postal Printing, 1998; 272, Istanbul
[7] Verep B, Hasanoğlu H, Mutlu T. A Case Study on the Effects of Trout Farms Waste Water on the Physicochemical Water Quality of the Stream, *Journal of Anatolian Environmental and Animal Sciences*, 2017; 2: 38-42 Doi: 10.35229/jaes.330437
[8] Anonymous, The Environmental Impact of Farming in Türkiye and Its Relationship with Tourism, Recreation and Special Protection Areas", TÜGEM, 1993; 1-185, Ankara.
[9] Food and Agriculture Organization (FAO) of the United Nations. The State of World Fisheries and Aquaculture, 2002, Rome.
[10] Teodorowicz M. Surface water quality and intensive fish culture, *Archives of Polish Fisheries*. 2013; 21: 65-111 Doi: 10.2478/aopf-2013-0007
[11] Martins C I M, Eding E H, Verdegem M C, Heinsbroek LT, Schneider O, Blancheton J P,d'Orbcastel E R, Verreth J A J. New developments in recirculating aquaculture systems in Europe: A perspective on environmental sustainability, *Aquacultural Engineering*, 2010; 43(3): 83-93 Doi: 10.1016/j.aquaeng.2010.09.002
[12] Sturrock H, Newton R, Paffrath S, Bostock J, Muir J, Young J, Immink A, Dickson M. Prospective analysis of the aquaculture sector in the EU-Part 2: characterization of emerging aquaculture systems, In: (IPTS) IP, ed. JRC Scientific and Technical Reports-EUR 23409 EN/2. Luxembourg: Office for Official Publications of the European Communities, 2008.
[13] Piper R G, Mc Elwain I B, Orme L E, Mc Craren J P, Flower L G, Leonard J R. Fish hatchery management, U.S. Fish and Wildlife Service, 1982, Washington, D.C.
[14] Caramel B P, Moraes M D A B, do Carmo C F, Vaz-dos-Santos A M, Tabata Y A, Osti J A S, Ishikawa C, Cerqueira M, Mercante C T J. Water quality assessment of a trout farming effluent, Bocaina, Brazil, *Journal of Water Resource and Protection*, 2014; 6:909-915 Doi: 10.4236/jwarp.2014.610086
[15] Garcia F, Kimpara J M, Valenti W C, Ambrosio L A. Energy assessment of tilapia cage farming in a hydroelectric reservoir, *Ecological Engineering*, 2014; 68:72-79 Doi: 10.1016/j.ecoleng.2014.03.076
[16] Lalonde B A, Ernst W, Garron C. Chemical and physical characterization of effluents from land-based fish farms in Atlantic Canada, *Aquaculture International*, 2015; 23(2): 535-546 Doi: 10.1007/s10499-014-9834-y
[17] Verdegem M C J. Nutrient discharge from aquaculture operations in function of system design and production environment, *Reviews in Aquaculture*, 2013; 5: 158-171
Doi: 10.1111/raq.12011
[18] Sindilariu P D, Brinker A, Reiter R. Factors influencing the efficiency of constructed wetlands used for the treatment of intensive trout farm effluent, *Ecological Engineering, 2009;* 35(5): 711-722 Doi: 10.1016/j.ecoleng.2008.11.007
[19] Lazzari R, Baldisserotto B. Nitrogen and phosphorus waste in fish farming, *Boletim do Instituto de Pesca*, 2008; 34(4): 591-600
[20] Beveridge M C. Cage aquaculture, Fishing News Books. (3rd ed.), 2004; 234

[21] Mavraganis T, Choremi C, Kolygas M, Vidalis K, Nathanailides C. Environmental issues of aquaculture development, *Egyptian Journal of Aquatic Biology and Fisheries.* 2020; 24(2): 441-450 Doi: 10.21608/EJABF.2020.85857
[22] Mpeza P, Mavraganis T, Nathanailides C. Dispersal and variability of chemical and biological indices of aquaculture pollution in Igoumenitsa Bay, *Annual Review and Research in Biology*, 2013; 3(4): 873-880
[23] Varol M. Use of water quality index and multivariate statistical methods for the evaluation of water quality of a stream affected by multiple stressors: A case study", *Environmental Pollution*, 2020; 266: 1154-1217 Doi: 10.1016/j.envpol.2020.115417
[24] Coldebella A, Godoy A C, Gentelini A L, Piana P A, Coldebella P F, Boscolo W R, Feiden A. Nitrogen and phosphorus dynamics in Nile tilapia farming in excavated rearing ponds. *Research, Society and Development*, 2020; 9(11): e1319119699 Doi: 10.33448/rsd-v9i11.9699
[25] Karakassis I, Pitta P, Krom M D. Contribution of fish farming to the nutrient loading of the Mediterranean, *Scientia Marina Barcelona*, 2005; 69: 313-321, Doi: 10.3989/scimar.2005.69n2313.
[26] Yeo S E, Binkowski F P, Morris J E. Aquaculture effluents and waste by-products characteristics, potential recovery and beneficial reuse, *NCRAC Technical Bulletins*, 2004; 6:45
[27] Ackerman D, Weisberg S B. Relationship between rainfall and beach bacterial concentrations on Santa Monica Bay beaches". *Journal of water and health*, 2003; 1(2): 85-89. Doi: 10.2166/wh.2003.0010.
[28] Varol M, Balci M. Characteristics of effluents from trout farms and their impact on water quality and benthic algal assemblages of the receiving stream", *Environmental Pollution*, 2020; 266(1):115101 Doi: 10.1016/j.envpol.2020.115101
[29] Tahar A, Kennedy A M, Fitzgerald R D, Cliford E, Rowan N. Longitudinal evaluation of the impact of traditional rainbow trout farming on receiving water quality in Ireland, *PeerJ*, 2018; 6, e5281, Doi: 10.7717/peerj.5281
[30] Anonymous. Quality Criteria of Inland Surface Water Resources by Class, Regulation Amending the Regulation on Surface Water Quality Management, Abolished Ministry of Environment and Forestry, 2015, Ankara
[31] Pulatsu S, Rad F, Köksal G, Aydın F, Benli A K, Topçu A. The impact of rainbow trout farm effluents on water quality of Karasu stream, Türkiye. *Turkish Journal of Fisheries and Aquatic Sciences*, 2004; 4: 9-15
[32] Ruiz-Zarzuela I, Halaihel N, Balcázar J L, Ortega C, Vendrell D, Pérez T, De Blas I. Effect of fish farming on the water quality of rivers in northeast Spain", *Water Science and Technology*, 2009; 60(3), 663-671 Doi: 10.2166/wst.2009.435
[33] Mavraganis T, Tsoumani M, Kolygas M, Chatziefstathiou M, Nathanailides C. Using seasonal variability of water quality parameters to assess the risk of aquatic pollution from rainbow trout fish farms in Greece, *International Journal of Energy and Water Resources, 2021;*5: 379-389 Doi: 10.1007/s42108-021-00141-5
[34] Boyd C E, Tucker C S. Ecology of aquaculture ponds, *In Pond aquaculture water quality management*. Springer, Boston, MA, 1998; 8-86
[35] Boaventura R, Pedro A M, Coimbra J, Lencastre E. Trout farm effluents: characterization and impact on the receiving streams", *Environmental Pollution*, 1997; 95(3): 379-387 Doi: 10.1016/S0269-7491(96)00117-0.
[36] Selong J H, Helfrich L A. Impacts of trout culture effluent on water quality and biotic communities in Virginia headwater streams, *The Progressive Fish-Culturist*, 1998; 60(4): 247-262 Doi: 10.1577/1548-8640(1998)060<0247:IOTCEO>2.0.CO;2

[37] Kendra W. Quality of salmonid hatchery effluents during a summer low-flow season, *Transactions of the American Fisheries Society*, 1991; 120(1), 43-51 Doi: 10.1577/1548-8659(1991)120<0043:QOSHED>2.3.CO;2
[38] Lemarié G, Martin J L M, Dutto G, Garidou C. Nitrogenous and phosphorous waste production in a flow-through land-based farm of European seabass (Dicentrarchus labrax), *Aquatic Living Resources*, 1998; 11(4): 247-254 Doi: 10.1016/S0990-7440(98)89007-4.
[39]Buhan E, Koçer T M A, Polat F, Doğan M H, Dirim S, Neary E T. Almus Baraj Gölü Su Kalitesinin Alabalık Yetiştiriciliği Açısından Değerlendirilmesi ve Taşıma Kapasitesinin Tahmini, *GOÜ. Ziraat Fakültesi Dergisi,* 2010; 27(1): 57-65 (in Turkish)
[40] Birici N, Saatçi Y, Güneş M, Bayraktar K, Şeker T, Karakaya G. Refahiye Köroğlu Deresi (Erzincan) Sularının Balık Yetiştiriciliği ve Su Kalitesi Açısından Değerlendirilmesi, *Uluslararası Erzincan Sempozyumu,* 28 Eylül-1 Ekim, Bildiriler Kitabı, 2016; 3:613-627 (in Turkish)
[41] Başaran K A, Aksu M, Egemen Ö. Ildır Koyu'nda (İzmir-Ege Denizi) Açık Deniz Ağ Kafeslerde Yapılan Balık Yetiştiriciliğinin Su Kalitesi Üzerine Etkilerinin İzlenmesi, *Ankara Üni., Ziraat Fak., Tarım Bilimleri Dergisi,* 2006; 13(1): 22-28 (in Turkish)
[42] Küçükyılmaz M, Koçer, M A T, Örnekci G N, Karakaya G, Uslu A A, Arısoy G, Alpaslan K, Türkgülü İ, Özbey N, *International Journal of Eastern Mediterranean Agricultural Research*, 2021; 4(1):15-31 (in Turkish)