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Geospatial Assessment of Trophic Status From a Dam Under Significant Agricultural Drainage at the Mid-Anatolia, Türkiye

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Research Article

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Abstract

The population of Anatolia is continuously growing and developing and it is under the deep influence of global warming. It is increasingly evident that more fresh water will be needed for drinking, irrigation and domestic use. This study aims to assess the water quality and trophic status of a dam (Bayramhacılı dam lake) under excessive agricultural irrigation threat using spatial and multivariate statistical analysis. In the study, the periodic changes in the eutrophic state of the dam lake were determined using global index categories, Carlson Trophic Status Index (CTSI = 66.7), Burns Trophic Level Index (BTLI = 6.4), and Shu Trophic State Index (STSI = 65.6). The two periodical averages of total phosphorus (TP), total nitrogen (TN), biological oxygen demand (BOD), (chemical oxygen demand (COD) and chlorophyll a (Chl_a) concentrations, which serve as an indicator of anthropogenic nutrient input, were determined to be 0.23, 31.28, 1.83, 8.99 and 48.1 µg/L, respectively. Trophic index distribution maps demonstrate that the dam's surface water displays considerable alterations, particularly during the dry season. This evidence supports the implementation of a local management model that addresses the issue of eutrophication. It is therefore imperative that on-site measures are taken without delay.

Keywords: Lake quality assessment, trophic index, spatial analysis, Bayramhacılı Dam Lake

Orta Anadolu'da Önemli Tarımsal Drenaj Altındaki Bir Barajın Trofik Durumunun Jeo-Konumsal Değerlendirmesi, Türkiye

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Öz

Küresel ısınmanın derin etkisi altında olan Anadolu'da nüfusun sürekli büyümesi ve gelişmesi içme, sulama ve evsel kullanım için daha fazla tatlı suya ihtiyaç duyulacağını giderek daha belirgin hale getirmektedir. Bu çalışmanın amacı, aşırı tarımsal sulama tehdidi altındaki bir barajın (Bayramhacılı baraj gölü) su kalitesi ve trofik durumunun mekansal ve çok değişkenli istatistiksel analizler kullanılarak değerlendirilmesidir. Araştırmada ötrofiksel durumdaki baraj gölündeki periyodik değişiklikler; global indeks kategorileri, Carlson trofik durum indeksi (CTSI = 66.7), Burns trofik seviye indeksi (BTLI = 6.4) ve Shu trofik durum indeksi (STSI = 65.6) ile belirlenmiştir. Antropojenik besin girdisinin göstergesi olan toplam fosfor (TP), toplam azot (TN), biyolojik oksijen ihtiyacı (BOD), kimysasal oksijen ihtiyacı (COD) ve klorofil a (Chl_a) konsantrasyonlarının iki periyodik ortalaması sırasıyla 0.23, 31.28, 1.83, 8.99 ve 48.1 µg/L olarak belirlenmiştir. Trofik indeks dağılım haritaları, baraj yüzey suyunun özellikle kurak mevsimde önemli değişiklikler gösterdiğini göstermektedir. Bu kanıt, ötrofikasyon sorununu ele alan yerel bir yönetim modelinin uygulanmasını desteklemektedir. Bu nedenle yerinde önlemlerin gecikmeksizin alınması zorunludur.

Anahtar Kelimeler: Göl kalitesi değerlendirme, trofik indeks, konumsal analiz, Bayramhacılı Baraj Gölü

Introduction

Lake and river water pollution is an important ecological issue in developing countries like Türkiye. A substantial body of research has demonstrated that natural processes exerting a considerable influence on water quality encompass mineral oxidation, soil erosion, weathering of bedrock, and climate, especially for dam lakes. The principal causes of the reduction in reservoir quality are human activities, including animal husbandry, irrigation, the inadvertent usage of pesticides and fertilizers in agricultural districts, and the discharge of domestic wastewater. Ensuring the quality of freshwater resources is crucial for promoting both human health and economic progress. Therefore, it is essential that sufficient attention must be paid to their enhancement and preservation. Rivers are the first places where pollutants from home wastewater and solid waste, veterinary and agricultural operations, and industrial discharges merge before moving on to lakes and seas. As dam lakes are continually subjected to new ecosystems, pollution from the surrounding environment offers considerable concern. As a result, to predict and manage possible changes in water quality, thorough evaluations and projections are crucial [1-6]

Nutrients, surfactants and other possible anthropogenic chemicals constitute one of the parameters that provide information about the water quality. The sources of these elements entering surface waters can be natural, domestic or agricultural high levels of trace elements and nutrition-compounds in water can have a toxic effect on aquatic organisms. The inputs of nutrient elements, referred to as nutrients, into aquatic environments typically originate from point and anthropogenic sources known as non-point sources. The quantification of pollutant loads from point sources is generally more controlled and manageable than non-point sources. It is established that the toxic effects of nitrate are less than those of nitrite and ammonium nitrate [7-9]. Controlling point and non-point pollution sources, in particular, is crucial when they are close to dams that provide drinking and utility water. Water contamination in reservoirs must be controlled to effectively regulate water quality. Water quality and availability are equally important, especially for power plants to continue operating [10-13]. Protecting and managing ecosystems (rivers, lakes, and wetlands) fed by water resources requires regular monitoring of the quality of the water at specified intervals, the identification of important variables influencing pollution, and the implementation of appropriate solutions. This is essential for maintaining ecological balance and making effective use of water resources [14, 15].

The sustainable use of dam lakes, which are established for a variety of purposes including the cultivation of plants, the pursuit of leisure activities, and the implementation of strategies for the management and control of eutrophication, should be subject to more precise examination and evaluation. This is necessary for several reasons, including the effects of climate change. A thorough grasp of how atmospheric phenomena, in-lake dynamics, and other environmental elements interact is necessary for the effectiveness of water quality monitoring techniques and systems [16, 17]. The objective of spatial analysis is to identify the factors affecting water quality, thus enabling the development of appropriate strategies to facilitate the effective management of water resources [18-21]. Consequently, in the context of water quality assessment, it is of the utmost importance to conduct a comprehensive, multi-dimensional analysis of the complex interactions between the surface water body and the surrounding region [22-26].

The effects of global warming are becoming increasingly evident in the form of drought, which is drying up Anatolia's water resources. In addition to the impact of human-induced water pollution, the scarcity of water for agricultural use is becoming a significant concern, contributing to the emergence of regional problems. In light of the aforementioned considerations, the study concentrated on the Bayramhacılı dam, which provides irrigation to approximately 3.415 hectares in the Kayseri/Nevşehir Cappadocia region, a pivotal agricultural zone in Anatolia that is grappling with the challenge of excessive irrigation. The purpose of this study is; a periodical, comprehensive and multi-dimensional determination of the physico-chemical parameters of the dam lake water. Also compare of the results with national/international criteria, to analyze the trophic status of the dam lake according to different indices based on GIS, and to discuss the protection of this dam, which is important in terms of sustainable energy needs with climate change oriented agricultural irrigation and hydropower plants.

Materials and Methods

This investigation was conducted at the Bayramhacılı Dam Lake, built along the boundaries of Kayseri and Nevşehir Province. To determine the trophic water quality in the center region of Anatolia, where the effects of drought and agricultural drainage waters are particularly severe, monitoring and evaluation studies were conducted in three stages. First, multidimensional statistical analyses including clustering, correlation, and principal component analysis (PCA) were performed on each outcome, focusing on the periodic dimension of chemical contamination in the water was addressed. Second, the trophic status of the reservoir water was evaluated using various ecological status indices (Carlson [27], Burns et al. [28], Shu [29]). Finally, the trophic status of the reservoirs was further assessed through spatial analysis utilizing geographic information systems (ArcGIS).

Study Area and Sampling

The Bayramhacılı Dam Lake, is located on the Kızılırmak River and falls inside the borders of both Kayseri Province and the Avanos District in Nevşehir Province. The dam lake provides irrigation water that is also used for recreational water and natural activities. Covering a fishing area of 460 hectares, Bayramhacılı Dam Lake is one of the significant inland water resources supporting fish production in addition to its hydropower capabilities. The most commonly caught fish species in the lake include

Leuciscus cephalus and Cyprinus carpio among others. Figure 1 displays the map with the study area and the marked sampling points. The dam features a concrete-capped rock fill and has a lake volume of 218 m³ at normal water height. It irrigates a total of 3.117 hectares of land [30].

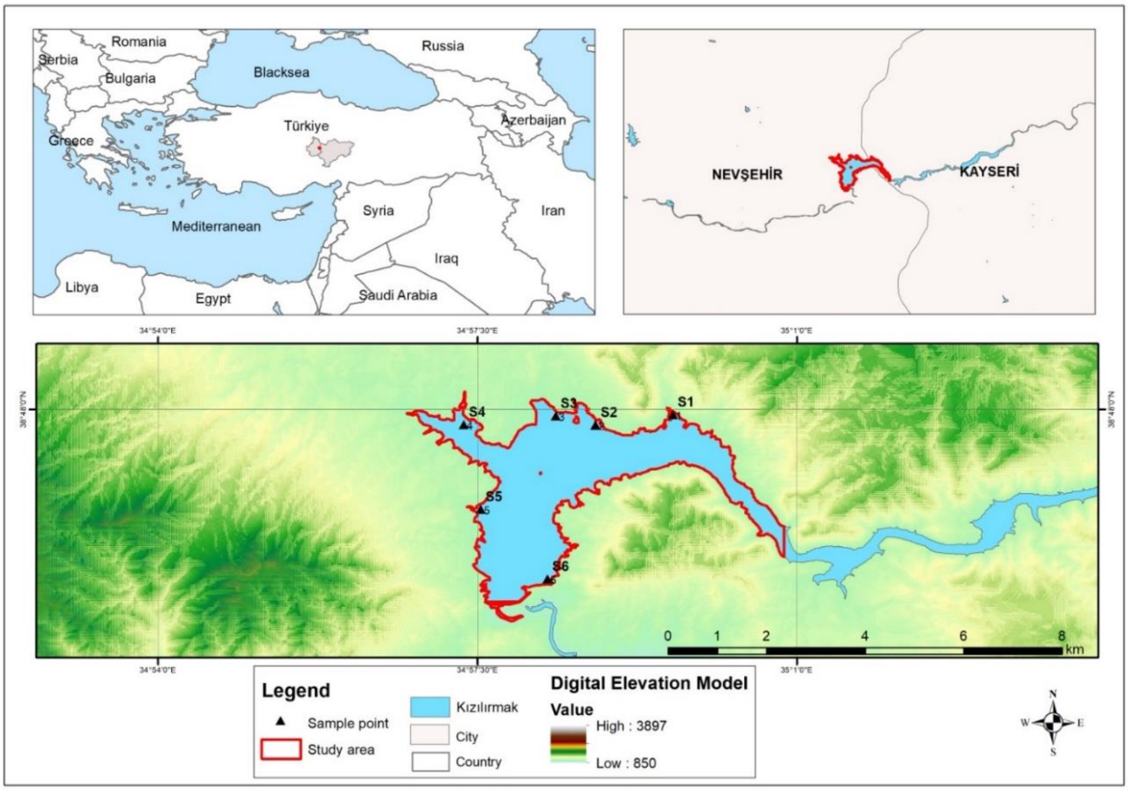

Figure 1. *Sampling points in the dam lake*

Sampling was carried out over two periods (wet and dry seasons/April 2020- July 2021). Seasonal sampling times were selected due to the local population drawing water from the dam lake for irrigation purposes and transporting it from the drainage areas to the lake. A periodic sampling program was established based on the planting and harvest schedules of agricultural products specific to the region, particularly grapes, pumpkins and potatoes. Surface water was collected in plexiglass sample containers from six locations during the two field research periods. The GPS coordinates of each location were recorded using a Magellan Exp710 and processed according to the WGS 1984 coordinate system. The coordinates of the stations where the samples were collected are provided in Table 1. Real-time fieldwork measurements of the water quality parameters including temperature, pH, dissolved oxygen (DO), total suspended solids (TSS), and electrical conductivity (EC) were taken using a portable Hach 40dQ multi-gauge probe. Additionally, fluorometric analysis was conducted to determine chlorophyll-a concentrations in surface water samples. Anionic surfactants, total phosphorus (TP), total nitrogen (TN), biological oxygen demand (BOD), chemical oxygen demand (COD) and Cl^- concentrations in samples stored at +4 ˚C were quantified using laboratory test kits (Hach-Lange) and conventional procedures [31]. All investigations were carried out using analytically pure chemicals, and spectrophotometric measurements were performed in a laboratory setting with the Hach Lange DR3900 thermo-reactor. (Hach Lange LT-200) and analytical scales (BEL).

Table 1. *GPS coordinates of each station*

Sampling Points	Latitude	Longitude
1	38.7991	34.9940
2	38.7972	34.9799
3	38.7988	34.9727
4	38.7972	34.9559
5	38.7817	34.9590
6	38.7690	34.9711

Eutrophical Assessment

In this research, the Carlson Trophic Status Index CTSI [27], Burns Trophic Level Index BTLI [28] and Shu Trophic State Index STSI [29] values were calculated to assess the periodical change in the trophic status of the dam's surface water. The Carlson index is commonly used by government officials and researchers as an indirect measure of algal biomass and serves as a key indicator of the health of aquatic ecosystems for the extent of lentic system eutrophication [32]. It is calculated mathematically based on the relevant equations for three parameters: chlorophyll-*a*, Secchi depth, and total phosphorus. In this study, the Carlson Trophic Status Index was derived from periodic Chl-*a* values. Equation 1 is as follows:

$$TSI(Chl\_a) = 10(6 - \frac{2.04 - 0.68 \ln Chla}{ln2}) \quad (1)$$

The Carlson trophic status index (CTSI) value: A value below 40 indicates oligotrophic water quality, values between 40 and 60 indicate mesotrophic quality, values between 60 and 70 indicate eutrophic quality, and values above 70 indicate hypertrophic quality [33]. Burns et al. [28] developed the Burns Trophic Level Index BTLI to assess the trophic status of lakes in New Zealand. This required modifying the Carlson TSI by removing the total nitrogen (TN) parameter. In this study, the seasonal trophic levels of the dam lakes were determined based on the average Chl-*a* value for the BTLI. Burns Trophic Level Index (BTLI) value: The classification of water quality levels is as follows: levels below 3 are considered oligotrophic, levels 3 - 4 are mesotrophic, levels 4 - 5 are eutrophic, levels 5 - 6 are super-oligotrophic, and levels above 7 are hypertrophic [34].

$$TLI(Chl\_a) = 2.22 + 2.54\log{(Chl_a)} \quad (2)$$

The method developed by Shu [29] to assess the periodic eutrophication of lakes, defined as the Shu model, calculates index values reflecting the current trophic state of the lake based on the algorithm defined below (equation 3), focusing on chlorophyll-a concentration. The unit of chlorophyll a concentration is µg/L. Shu Trophic State Index (STSI) value: ≤20 indicates oligotrophic, ≤40 mesotrophic, ≤70 eutrophic, ≤80 hypertrophic and ≤100 extremely hypertrophic water quality [29].

$$TSI(Chl\_a) = 10(2.46 + \frac{\ln(chl-a)}{\ln(2.5)}) \quad (3)$$

The trophic status of the Bayramhacılı dam lake was established in accordance with the relevant legislation of Türkiye. This legislation, known as the "Surface Water Quality Management Regulations (SWQR)" was published in the Official Gazette of the Republic of Türkiye in 2012. Table 2 shows the trophic classes defined by the SWQR [35]. By using the trophic status classification of lakes and ponds specified by the National SWQ regulations of Türkiye, the trophic level of the irrigation/energy dam has been revealed based on CTSI, BTLI and STSI values.

Table 2. *Trophic Classifications based on SWQR according to the legislation of Türkiye [35]*

Trophic Classes	TP (µg/L)	TN (µg/L)	Chl_*a* (µg/L)	Secchi Depht (m)	DO (mg/L)
Oligotrophic	<10	<350	<3.5	>4	>7
Mesotrophic	30-50	650-1000	9-15	2.0-1.5	6-4
Eutrophic	100	1500	25	1	3
Hypereutrophic	>100	>1500	>25	<1	<3

Statistical and Geographical Studies

All data computations and statistical analyses were performed using SPSS 22, while spatial analyzes were performed using ArcGIS 10.8. The maps produced to compare the effects of periodic changes on the trophic/water quality of the dam lake were created using the Inverse Distance Weighted (IDW) interpolation technique. Tercan and Dereli [36] noted that the method allows the evaluation of the influence of each point on the other based on the inverse of the distance between the points. In this context, the periodic changes in the physico-chemical quality of pond surface water was evaluated geographically.

Results and Discussions

Physical and Chemical Results of the Dam Lake Water

Figure 2, 3a and 3b, shows the two-period graph for physico-chemical parameters and the regional distribution maps of metrics related to surface water quality, respectively. The analysis of parameter results and preparation of spatial maps represents a rapid and efficacious approach to the assessment of water quality. The application of spatial analysis has revealed significant alterations in water quality, including increases in nutrient and pigment concentrations observed in the southwestern area of the lake during the dry period. These changes are likely a consequence of anthropogenic impacts and land use practices.

During the summer, conductivity rises by an average of 1324.3 µS/cm due to the geological structure of the lake environment (Figure 2). Electrical conductivity (EC) values are in the range of 920-1020 µS/cm during the wet period, while 1220-1414 µS/cm during the dry period, and reaches the highest values as it approaches the southern parts of the dam. According to the Turkish Surface Water Quality (SWQ) Regulation [35], Bayramhacılı Dam is classified as medium-category water quality. In addition, in terms of irrigation water, the dam pond is in the 'high saline water' category and has been determined to have permissible water quality. As seen in Figure 3a, the pH value (>9) reached the highest possible level (highly alkaline) in the northwestern sections of the dam.

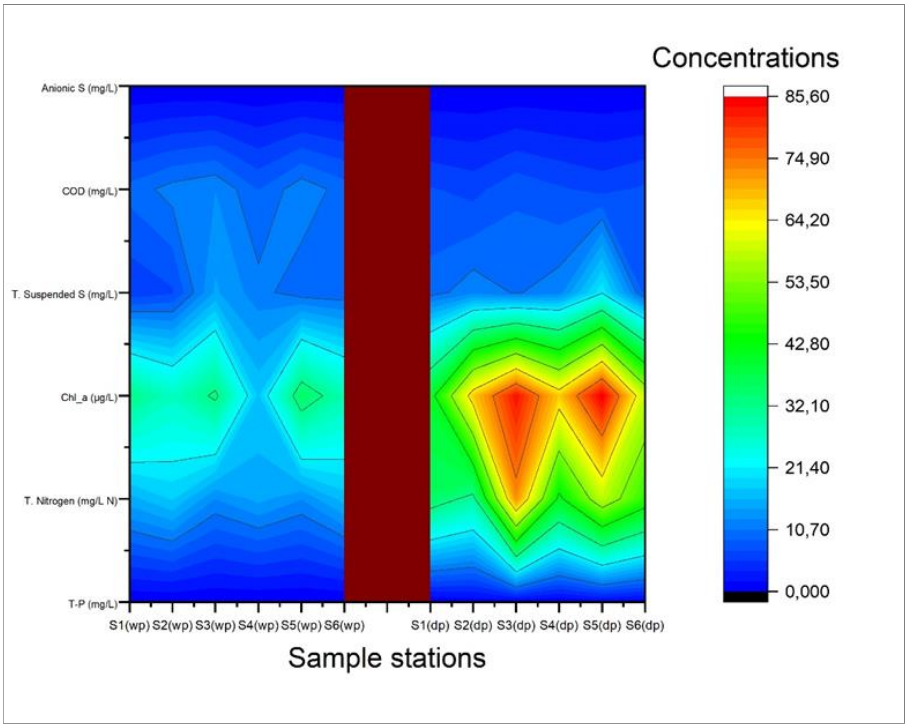

Figure 2. *The distribution of average physico-chemical parameters based on sampling stations during wet (wp) and dry (dp) periods.*

It was established that the mean annual concentration of total suspended solids (TSS) in the lake was 11 mg/L. It is hypothesized that the TSS load is a consequence of agricultural drainage and the erosion of the upper soil layers into the aquatic environment. Because of the heavy precipitation during the dry period, TSS and nutrient concentrations were higher. In Korean reservoirs, the time period has a major impact on the hydrology, nutrients, and suspended solids concentration [37]. The current concentration of dissolved oxygen (DO) in the lake is 7.5 mg/L, which represents the lowest recorded value even during the dry season. This can be considered as an indication that particle pollution in the lake is not a permanent issue.

The periodical average of the surface water temperature ranges from 14.4 to 19.07 °C. The lowest recorded temperature of the surface water in the dam lake was 13.6 °C (during the wet season, at station no. 3) while the maximum temperature of the surface water was 20.2 °C (in dry season, at station no.6). Although the northeast of the dam lake had a low temperature, it was found that temperatures increased in the southern parts (Figure 3a).

During this investigation, the Chl_*a* value was measured and monitored in all samples to evaluate the periodic changes in the TP and TN levels in the lake, as well as stability of the dam lake's trophic state. The mean concentration of chlorophyll-a in the dam lake was 29.07 µg/L throughout the wet period, with a local increase in the dry period, reaching an average of 67.1 µg/L (Figure 3b).

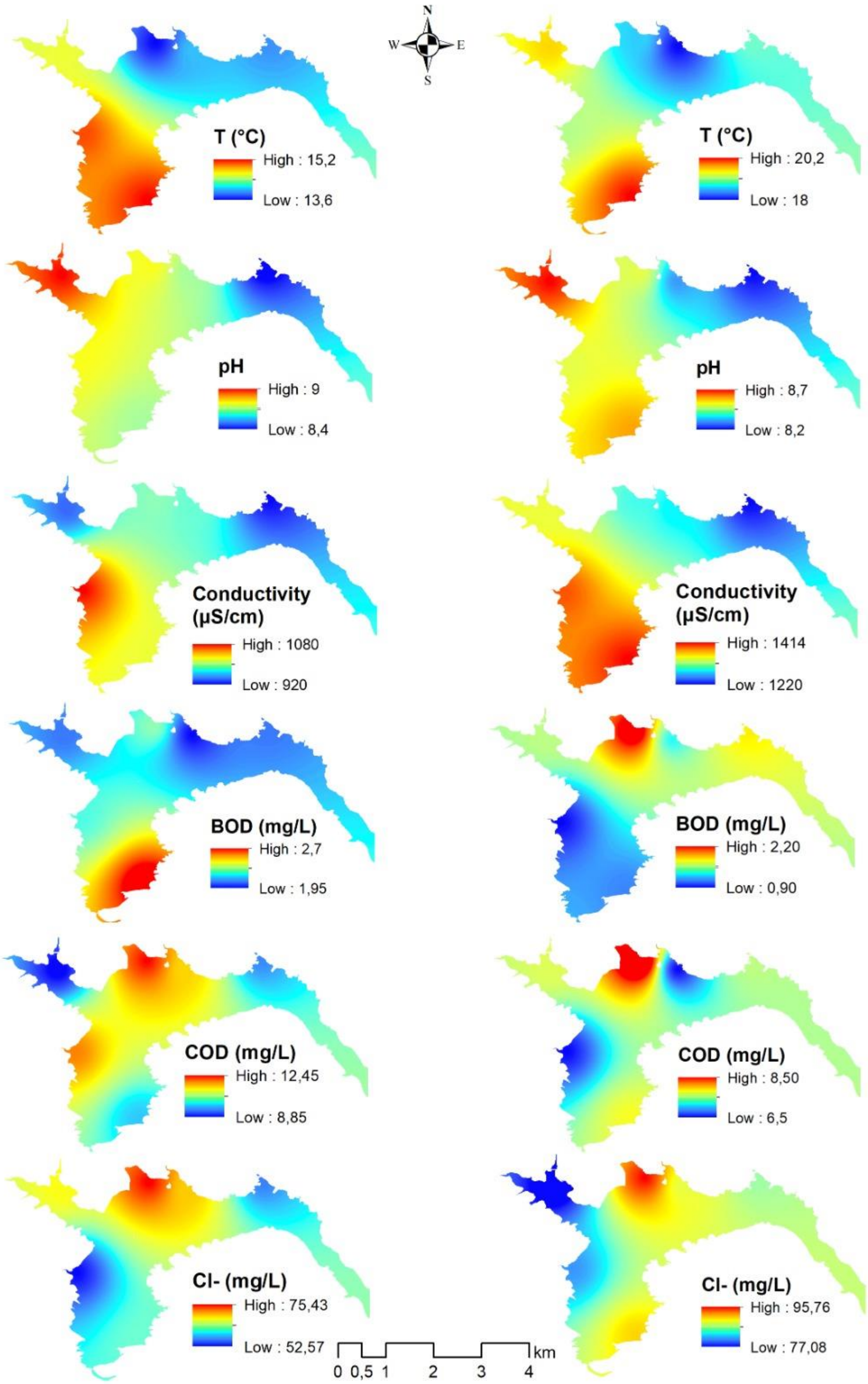

Figure 3a. *Geo-spatial distribution maps of surface water quality parameters (T, pH, EC, BOD, COD, Cl^-, DO) over two periods*

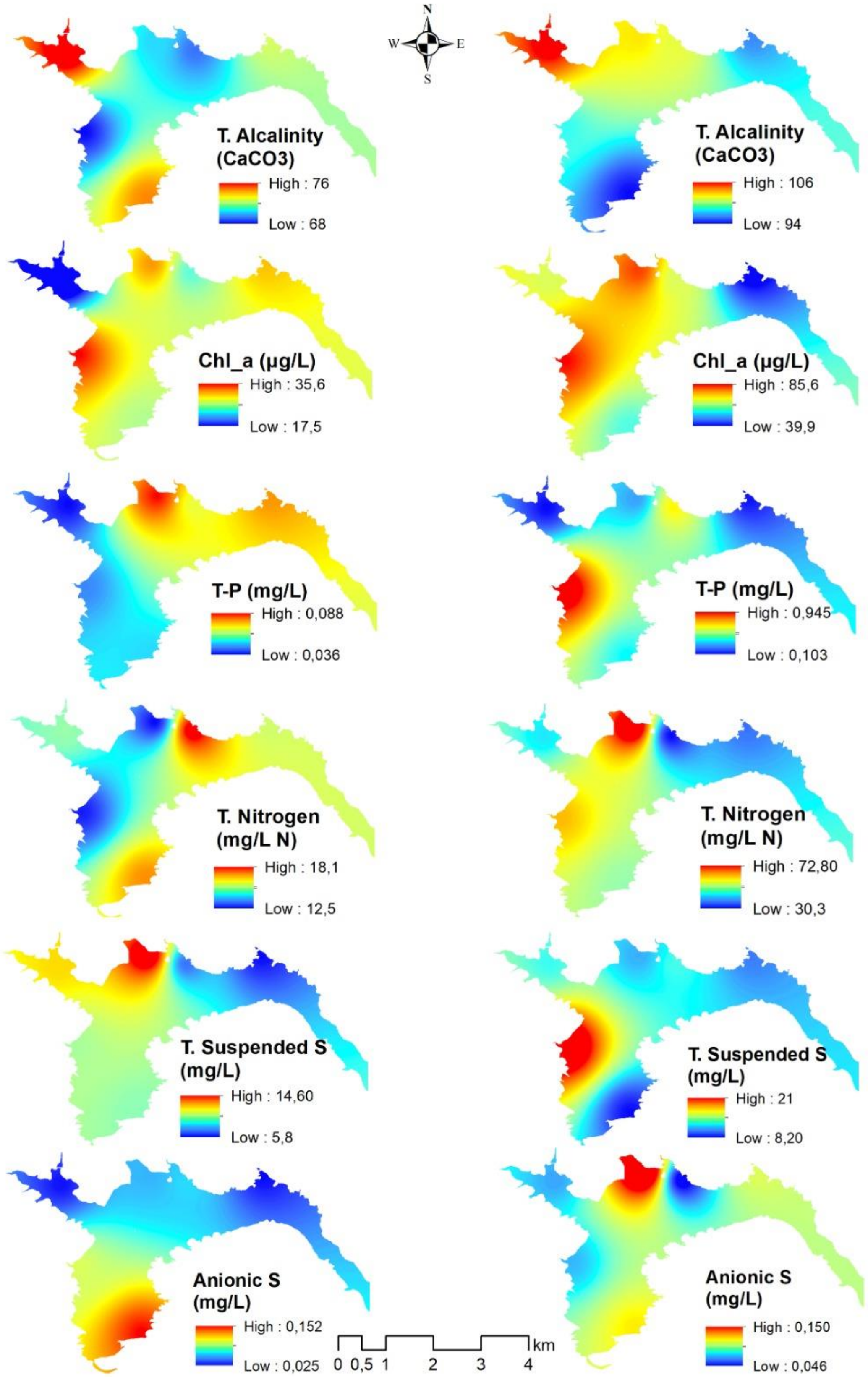

Figure 3b. *Geo-spatial distribution maps of surface water quality parameters (TA, Chl_a, TP, TN, TSS, AS) over two periods*

The periodic effect is a significant factor influencing the alteration of total nitrogen and phosphorus concentrations. In the dam water where the highest TN concentrations were detected during the dry period, the increase in the nutritional input is considered to be the most significant factor influencing the lake's trophic state. An increase in phosphorus was observed at the 3rd station in the wet period and at the 5th point in the dry period (Figure 4). In aquatic environments near agricultural lands, the concentrations of phosphate and nitrogen substances may be considerably increased by agricultural activities and irrigation techniques [38]. Moreover, pollution may arise from sewage, garbage, waste, and the industrial facilities in the area. The mean value in our study has been found to be 0.79 mg/L, which has been considered to be a highly dangerous concentration for aquaculture and aquatic life, potentially resulting in sudden mortality. The sharp rise in the levels recorded at all monitoring stations on the dam is likely a result of the phosphatic fertilisers leaching into the water. Furthermore, it is thought that the influx of water from urban waste and agricultural areas into the lake during the transition from the dry season to the rainy season contributes to the observed increase in nutrient levels in the lake’s surface water.

Similarly, the area is a center for subterranean travel, with the end of fall being the peak population for the city. Although summer-drying streams contribute minimal waste to the lake, rainfall affects this situation. The average total alkalinity (71.5 mg/L) observed at the lowest levels during the rainy season increased to high values (99.5 mg/L) during the dry season, particularly in the lake's northeastern region (Figure 3b).

It was observed that the highest TDS and EC values were concentrated in the western area and at the southern end of the reservoir during the dry period. Especially the COD values in the central-northern parts of the lake are extremely high for an irrigation dam suggesting an attempt. The sources of organic matter (BOD and COD) in reservoirs can be classified as either autochthonous or allochthonous. During rainfall events, runoff from overland water flow is the primary source of allochthonous organic matter entering aquatic systems, whereas phytoplankton and hydrophytes produce autochthonous organic matter through photosynthesis [39]. While COD concentrations have generally been rising, BOD concentrations in the majority of lakes and reservoirs have been steadily declining. This suggests that the biological effluent treatment process may not be effectively breaking down the significant amounts of nonbiodegradable organic matter in the influent [40]. In accordance with the classification standards for inland water resources [41], the surface water quality of the lake can be classified as 'medium' quality.

Evaluation of the Trophic Status of the Dam Lake

The eutrophication index, a key metric in the assessment of lake water quality, reveals a notable shift in trophic levels throughout the year, indicating a considerable degree of pollution in the lake. A description of the classification scale utilized in the Carlson Trophic Status Index (CTSI) ranges from 0 to 100, and the findings of this regional study show that the mean CTSI for periodic Chl_*a* is 63.38 in the wet period and 70.04 in the dry period. The overall annual mean CTSI is 66.7.

The hierarchy of classification for Burns Trophic Level Index (TLI) ranges from 0 to 7. In this regional study, the average BTLI during the wet period was calculated to be 5.91 for Chl_*a*, and increased to 6.83 during the dry period. The annual average BTLI was determined to be 6.37. These results indicate that the lake can reach regional hypereutrophic limits (Figure 4.).

The classification scale of Shu Trophic State Index (STSI) ranges from 0 to 100. The findings of this regional study showed that the average STSI for periodic Chl_a reached 61.1 in the wet period and 70.18 in the dry period, and the annual average STSI was calculated as 65.64. According to these results, while the lake is classified as mesotrophic during the wet period, it becomes eutrophic during the dry period.

The index values (CTSI, BTLI and STSI) indicate that Dam Lake of Bayramhacılı is hypereutrophic, which is evidenced by the elevated levels of phosphorus (P) and nitrogen (N) in the surface water. Similarly, other studies have indicated a notable enhancement in eutrophic state during the late spring-period, when temperature typically rises and precipitation declines [42, 43]. Investigations on the trophic structure of ecosystems in eutrophic lakes [44-47] found that TSI index values determined according to the average of chlorophyll-a concentrations, were higher during the dry period compared to the rainy period. A similar trend was observed in the TSI values calculated in this study (Carlson TSI 70.04/63.08, Burns TLI 6.83/5.91 and Shu TSI 70.18/61.10, Figure 4).

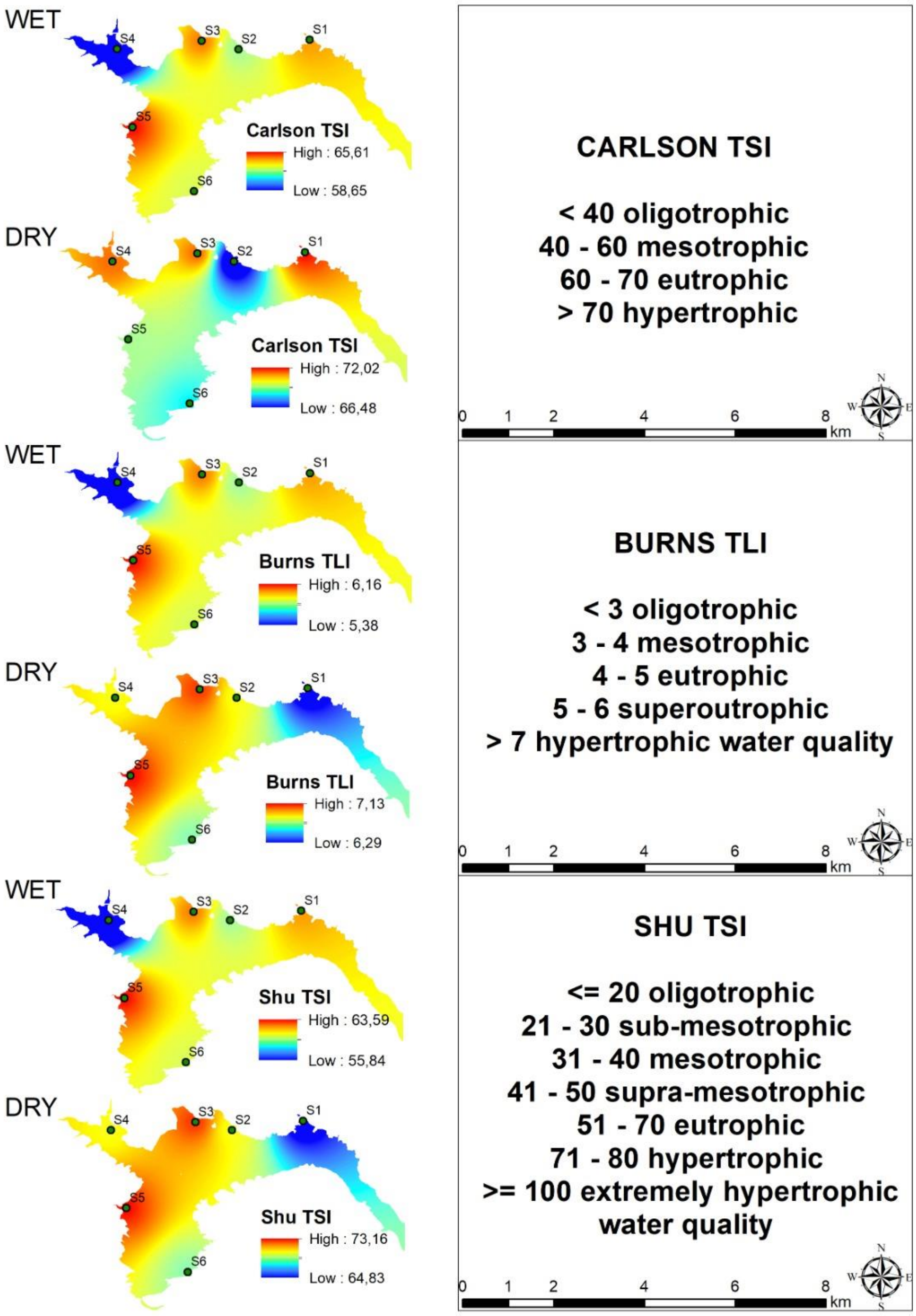

Figure 4. *Geographical analysis of periodic trophic status index values in the dam lake*

Statistical Observations

The principal components analysis (PCA) with varimax rotation yielded two variables with an eigenvalue exceeding one, collectively explaining 64% of the total variance (Figure 6). Based on the loading levels, Liu et al. [48] categorized the factor loadings as "strong (>0.75)," "moderate (0.75 – 0.50)," and "weak (0.50 – 0.30)". TN, Cl-, TP exhibit a markedly positive charge (> 0.75) in varifactor 1 (VF1), which accounts for 45.99% of the total variance. Conductivity, alkalinity and pH are moderately positively charged, while COD and TN are strongly positively charged. Elevated BOD and

COD levels indicate the presence of organic contamination in the reservoir. Nitrogen fertilizers, animal manure and chemical fertilizers/ pesticides are intensively used in the agriculture of the region. The strong link between chlorophyll-a values and COD and total phosphorus/total nitrogen coincides with the high correlation results (Figure 5).

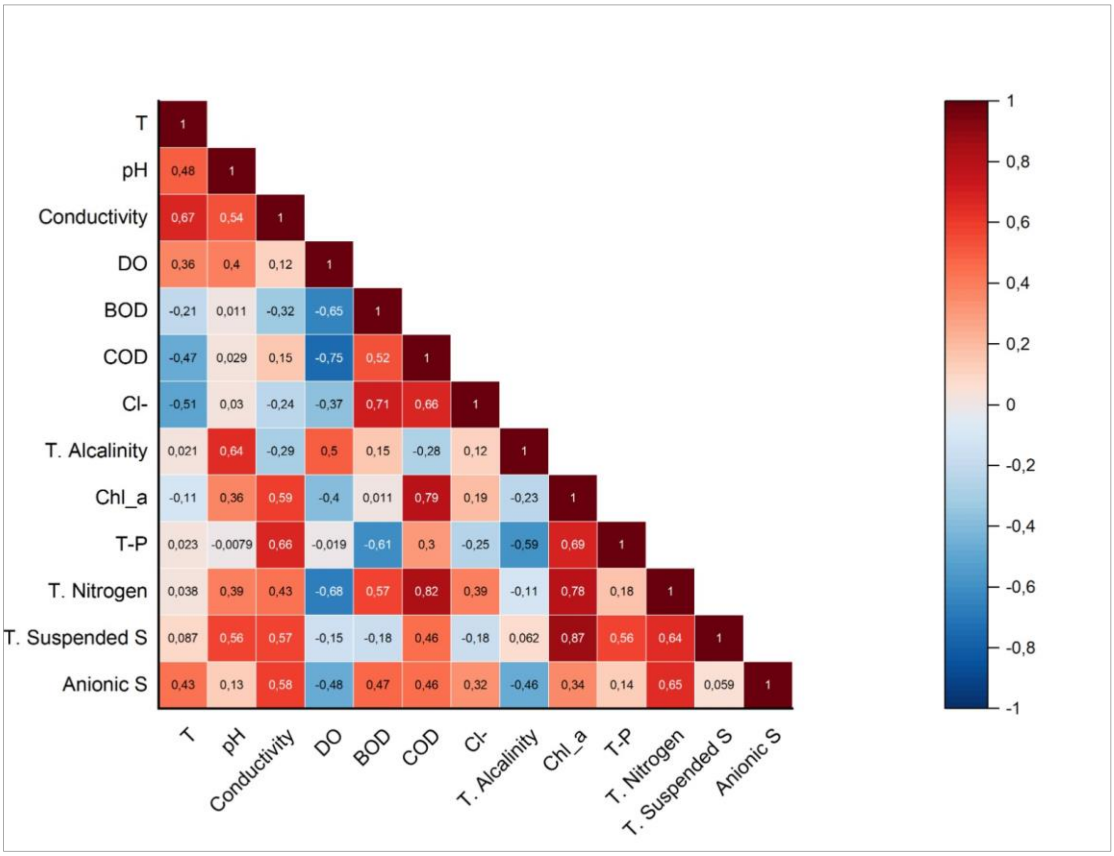

Figure 5. *Spearman's correlation between physicochemical parameters*

The strong positive relationship between anionic surfactants, conductivity and total nitrogen (TN) is typically linked to domestic waste. To identify the possible sources and factors influencing the dam's water quality, a principal component analysis (PCA) and a factor analysis (FA) were carried out. Due to the strong positive correlation between TN/TP and BOD in VF1, it is the object in question represents agricultural drainage (Figure 6). Representing 27.10% of the total variance in VF2, strong positive charges are found in T, DO, and TA, but strong negative charges are found in Chl_*a*, according to the data (Figure 6). In accordance with the findings of VF2, erosion and surface runoffs are on effective the water quality of the Dam Lake of Bayramhacılı. The water quality of a lentic ecosystem was evaluated using FA and CA in a study conducted at Uluabat Lake, Türkiye [49]. Twelve sampling sites were divided into two clusters by CA, and three components accounted for 77.35% of the total variance, according to FA. The results of the dual clustering analysis indicate the formation of two principal stationary clusters, S5 and other stations (Figure 7). Among the chemical parameters measured are pH, alkalinity and DO, which form a cluster among themselves. In contrast, other parameters are clustered. Upon examination of the subclusters of the other main group, small clusters between T (ºC)-conductivity and surfactants, between COD-TN and Chl_*a*-TSS and BOD-Cl^- are distinguished from the others. Anthropogenic activity impacts in the dam are indicated by the geographic variations of these metrics.

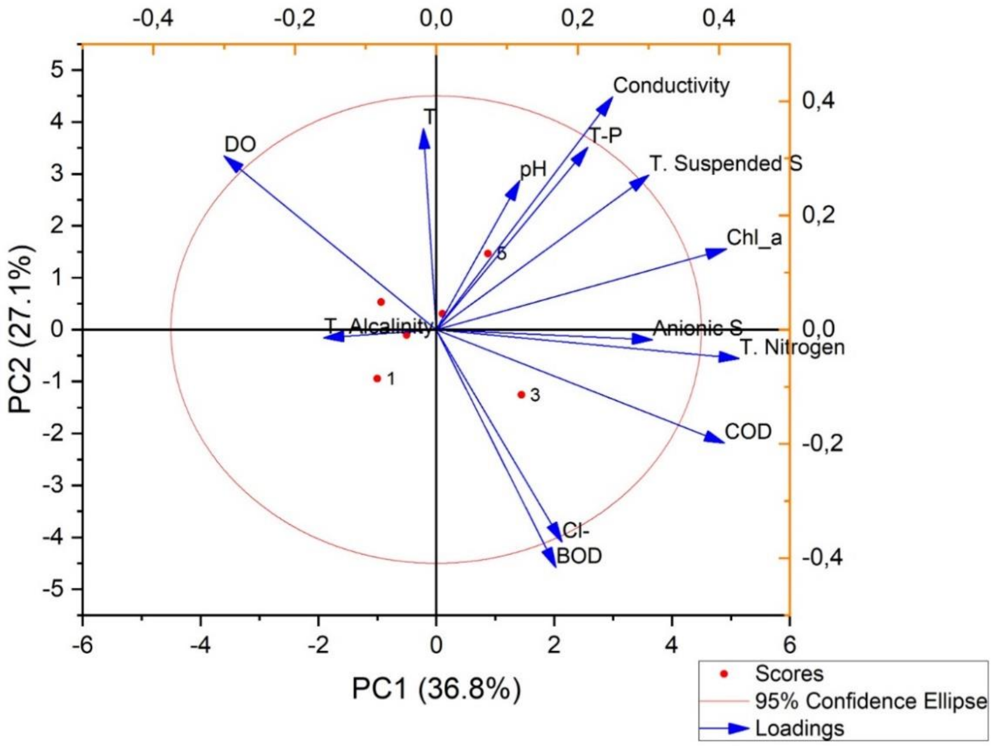

Figure 6. *PCA/FA of measured physico-chemical parameters*

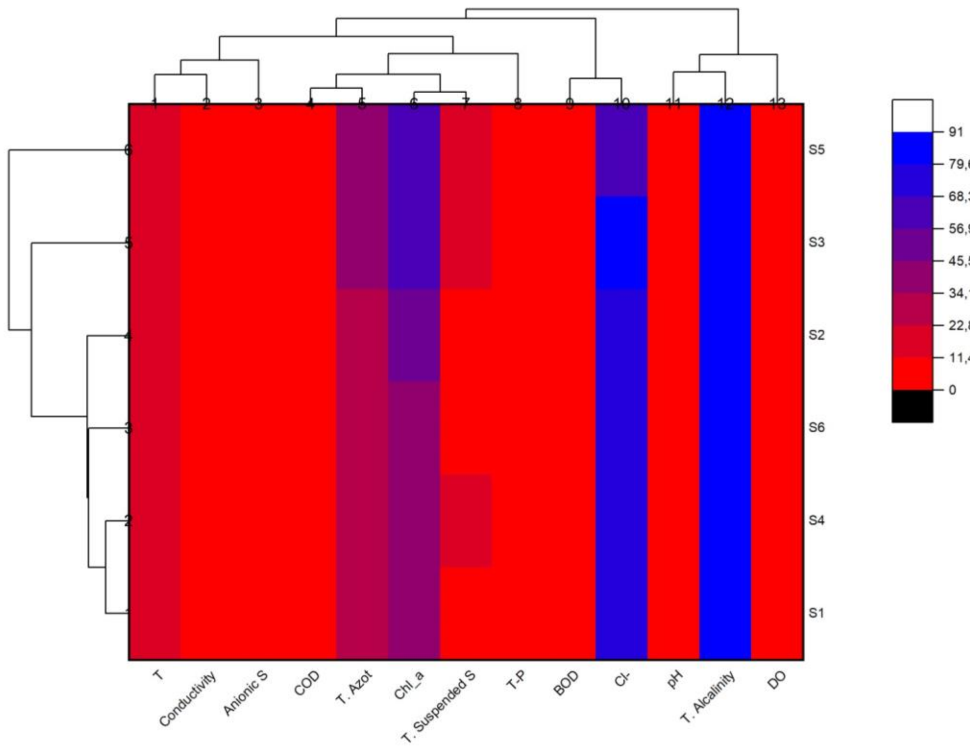

Figure 7. *Cluster analysis of measured physico-chemical parameters*

Conclusions

In this study, the periodic changes in the state of eutrophication and water quality of a HEPP dam lake facing the possibility of a drought and agricultural drainage were evaluated using statistical, ecological indices and geo-spatial analyses. The results of thematic maps and multi-statistical analysis indicate that seasonal and extreme fluctuations in nutrient loadings may be caused by agro-irrigation discharges that directly impact the eutrophication of lakes. The most significant finding indicative of eutrophication in the Dam was the minimum and maximum values of chlorophyll-a (Chl_*a*), which ranged from a minimum of 17.5 μg/L to a maximum of 85.6 μg/L. The average TSI values were determined from the chlorophyll-a measurements obtained during the dry period were found higher compared to the rainy period.

For this reason, some suggestions for decision makers are presented below in order to extend the life of the dam lake in providing both irrigation and HEPP energy.

i. It is necessary to guide the region towards good agricultural activities that will be carried out with reduced use of inorganic chemicals.
ii. The implementation of irrigation water quality controls and the application of right amounts and forms of fertilizer, in accordance with soil analysis, will be an effective strategy for reducing pollution.
iii. It is evident that enhanced pollution control within the dam lake system is imperative to attain optimal chemical and ecological status. This can be accomplished by implementing wastewater treatment facilities while maintaining a minimal level of agricultural pollution within the system. Thus, it is necessary to prevent sewage and solid waste from mixing into streams with effective removal and control techniques, thus preventing possible pollutants from mixing into the dam lake.

As a result, the findings obtained within the scope of this study will guide future studies within the framework of the sustainability of the dam lake in energy and irrigation. It will also contribute to the eutrophic restoration of the dam lake and to make managerial decisions compatible with the drought-based climate, which is expected to improve its regional influence further.

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Conflict of Interests The authors stated that there are no conflict of interest in this article.

Authors Contribution M. A. D. performed statistical calculations and provided graphs, worked with GIS to map and interpret the spatial distribution of the data and helped write the manuscript, H. C.

carried out the experimental studies and edited the original draft manuscript, E. K. assisted with the experimental studies, processed all data and helped write the manuscript. All authors read and approved the final version of the manuscript.

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