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Original Research

Determination of Drinking Water Quality of Public Fresh Water Fountains in Sivas Province Using Multivariate Statistical Methods

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Abstract

This research was carried out in order to evaluate the physicochemical variables of public fountain waters with multivariate statistical methods between April 2019 and February 2020 in Sivas province of Turkey. In this context, 12 physicochemical variables belonging to 6 selected stations were examined. The coefficient value of the Kaiser-Mayer-Olkin test was analyzed as 0.627 and the significance value of the Bartlett's test as 0.00. According to these two values, the data set was found adequate for factor analysis. Four factors with Eigenvalues greater than 1 were determined according to the results obtained from the factor analysis. In the research 74.7% of the total change can be explained by these four factors. As a result of the research, significant similarities were observed between the structure obtained by rotated factor analysis and the structure obtained by cluster analysis. All of the 12 physicochemical variables clearly show that the fountain water samples in Sivas province meet international standards for drinking water. However, the quite low average fluoride value may create a risk of tooth decay for the local people who constantly consume fountain waters as drinking water in Sivas.

Keywords: multivariate analysis methods, public fountains, water quality

Introduction

Societies that developed economically and sociologically in the historical process have built various water structures to meet their water needs. Water structures have become indispensable for the cities and played a major role in the physical creation of the province. Fountains are characterized in water structures. In recent years, the unconscious development plans made in cities cause the fountains to decrease and disappear day by day. Sivas is an important province of history and culture. The history of the Sivas province is based on the 5th and 4th millennium BC according to the archaeological studies. The province came under Hittite, Roman, Byzantine, Seljuk and Ottoman domination, respectively. The province, which was called "Sebasteia" in history, was changed to "Sivas" during the Turkish period. The fountains that the Turks made as charity were built in settlements and rural areas. The fountains are located in places that are most suitable for the benefit of the society. Sivas is a province where there are plenty of drinking water

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which are described as both streams and fresh water. The source of fresh water in Sivas is the areas called Meraküm Plateau and Tavra Strait [1]. Three streams pass through the province of Sivas [2]. Therefore, fountains and other water structures play a major role in the physical creation of Sivas province. Thanks to the special attention and sensitivity of Sivas society to water and fountains, fountains that have survived to this day are still encountered. The quality of the water is of high importance in terms of drinking. With the rapid increase in the world population, the need for drinking and using water also increases. Water resources are getting polluted day by day and the availability of a quality water source suitable for consumption becomes limited. In the case of suitable water sources, drinking water quality is negatively affected due to disruptions in the treatment, distribution and storage of these waters. There is a relationship between drinking water and human health. Water that is qualified as drinking water should be suitable for health. Therefore, it is immensely substantial to provide the required quality in drinking water supply systems and systems where these waters are delivered to the consumer. It is of large significance that the drinking water has the required quality and that it is monitored. The research was carried out to determine the physicochemical quality of public fresh water fountains, which are frequently used as drinking water in Sivas province, with multivariate statistical methods.

Material and Methods

Research Area

Sivas selected as a research area is situated in central Anatolia region of Turkey. Sivas, with a surface area in terms of 28.619 km^2 of land width is Turkey's second largest province. It is on quite gypsiferous and calcareous geological structure. The average elevation of Sivas province is over 1000 meters. Most of Sivas lands are located in Kızılırmak and the other part is located in Yeşilırmak and Fırat basins. According to the results of the census on the address based population system in Sivas province, a total of 638.956 people lived in 2019, while the province center has 381.325 people. The population of Sivas decreased by 7.652 persons compared to the previous year. Population growth rate in Sivas province was determined as -1.18% in 2019. There are 22 persons per square kilometer in Sivas. Sivas is a province with low population density. 59.68% of Sivas population live in Sivas province center and 40.32% live in rural areas [3]. Approximately 47% of Sivas drinking and utility water needs are met from groundwater and 53% from surface water resources. Daily water demand for Sivas province varies between 900 and 1.100 L/sec. The groundwater is supplied by the groundwater drainage and wells in the Tavra Valley. The surface water source of the Sivas province is provided from the 4 Eylül Dam built on Mısmılırmak for drinking water. Therefore, drinking and utility water of the province is provided from both groundwater and surface water sources [2]. In Sivas province, 76.5% of the houses supply their drinking water from the tap water [4]. The waters coming from the 4 Eylül Dam and Tavra Valley are treated at the drinking water treatment plant and supplied to the province network. Since 2015, chlorine-oxygen based disinfectant technology has been used in Sivas Drinking Water Treatment Plant for disinfection purposes. Thus, purified water is supplied to the entire province of Sivas.

Sample Collection and Stations

This research was conducted in Sivas province between April 2019 and February 2020. Public fountain water samples were collected from six stations seasonally in Sivas. In the fountains sampled, the faucet was opened to the end and the water was poured for one or two minutes. The samples were placed in 0.5-liter polyethylene bottles without any air gap and transported to the laboratory. Before taking a water sample, the bottles were rinsed at least three times with some fountain water. The fountains from which the samples were taken were selected considering the usage intensity of the public. Samples were collected seasonally from the fresh water fountains listed below for a period of one year including spring, summer, autumn and winter periods. The fountain, which was chosen as the number 1 station, is located next to the Sivas Train Station. Built using marble material, the fountain is placed on three stone platforms one on top of the other. The inscription on the fountain is made of brass. It is written on the inscription "It was made by Divriğili Ömer Oğlu Naci Bey in 1932". This fountain has survived until today by preserving its original form. Station 2 was built in 2000 and is located near the Sivas Congress Building. "Medina Kurugöl Hayratı" is written on its inscription. This fountain was built using marble material. Station 3 was built in 2002 and is located next to the Sivas Public Education Center Building. "Osman and Zeynep Doğan Hayratı" is written on its inscription. This fountain was built using marble material. Station 4 was built in 2017 and is located in front of the Sivas Cumhuriyet University Central Cafeteria. On his inscription "Ilyas Dağlar Hayratı" is written. This fountain was built in Seljuk architectural style. Station 5 was built in 2016 and is located at the entrance of the Paşabahçe Picnic Area. On his inscription, "Mihr-i Vefa Fresh Water" is written. This fountain was built using marble material. Citizens coming to the Paşabahçe Picnic Area for Mihr-i Vefa fresh water line up to fill their bottles with water from this fountain. The water of this fountain is of great interest to the people of Sivas. Station 6 was built in 1837 by Sultan II-Mahmut. It is located in Sivas province center, opposite the historical Taş Inn. Two marble reliefs and two indigenous columns and capitals are decorated with kenger leaves and divided into three with moldings. This fountain was repaired in 2007 and the old trough was removed and a new trough made of marble was placed in its place. This fountain has been flowing for about 180 years.

Water Quality Analyses

The pH was analyzed on stations utilization a digital pH/ORP meter (HI98121 - Hanna Instruments). Ammonium, nitrite and nitrate were measured on stations by colorimetric method using Aquamerck Company test kits 1.08024.0001, 1.08025.0001 and 1.11170.0001 respectively. Fluoride and iron were measured on stations by colorimetric method using Chembio Company test kits CB5100 and CB5090 respectively, whereas potassium was analyzed in the lab by titrimetric method using Chembio Company test kit CB5390. In order to determine the biochemical oxygen demand values (BOD_5), special BOD bottles were filled with water sample so that there was no air gap, closed tightly, brought to the laboratory on the same day, and the amount of dissolved oxygen was analyzed by keeping it in the dark incubator at 20ºC for 5 days. The difference between the dissolved oxygen amounts measured the first and after 5 days was determined as the BOD_5 value. Chloride, dissolved oxygen and total hardness were analyzed in the lab by titrimetric method using Aquamerck Company test kits 1.11106.0001, 1.11107.0001 and 1.08039.0001 respectively. Calcium and magnesium were calculated according to the formula of total hardness change [5].

Statistical Analysis

In the research, principal component analysis, factor analysis and cluster analysis and Pearson correlation analysis, which are among the multivariate statistical analysis methods, were applied on the physicochemical variables calculated in the public fountain water samples taken from the stations determined in Sivas province. Kaiser-Meyer-Olkin (KMO) and Bartlett tests were used to determine the compatibility of the data set in the factor analysis applied to group the physicochemical variables of the fountain water samples. In determining the factors, varimax technique with Kaiser normalization was used for the rotation from principal component analysis method. The factors were classified as strong ($F>0.75$), moderate ($0.50<F<0.75$) and weak ($0.30<F<0.50$) according to their effect sizes in factor analysis [6]. All mathematical and statistical results were performed by using Microsoft Office Excel 2016 and IBM SPSS version 22.

Results and Discussion

In the research area, 12 different physicochemical variables were analyzed to determine the drinking water quality of public fresh water fountains with multivariate statistical methods. The analyzed variables are pH, ammonium, nitrite, nitrate, chloride, flouride, iron, potassium, BOD_5, total hardness, calcium and magnesium. Descriptive statistics of these variables are introduced in Table 1. The values of the physicochemical variables analyzed over a one-year period in water samples taken from fresh water fountains changed as follows; pH 7.56-8.65, ammonium 0.00-0.16 mg/L, nitrite 0.00-0.01 mg/L, nitrate 2.30-11.00 mg/L, chloride 4.00-14.00 mg/L, flouride 0.01-0.50 mg/L, iron 0.30-0.50 mg/L, potassium 20.00-40.00 mg/L, BOD5 0.50-1.40 mg/L, total hardness 3.20-14.60 ^{0}dH, calcium 22.85-104.24 mg/L and magnesium 13.70-62.49 mg/L.

Table 1. Descriptive statistics of variables.

Variables	Units	N	Range	Min	Max	Mean	±SD	Variance	Skewness	Kurtosis
pH	pH unit	24	1.09	7.56	8.65	8.13	0.29	0.08	-0.270	-0.645
Ammonium	mg/L	24	0.16	0.00	0.16	0.06	0.07	0.00	0.551	-1.859
Nitrite	mg/L	24	0.01	0.00	0.01	0.00	0.00	0.00	2.422	4.210
Nitrate	mg/L	24	8.70	2.30	11.00	4.03	2.20	4.87	1.355	2.570
Chloride	mg/L	24	10.00	4.00	14.00	8.16	2.20	4.84	0.678	1.057
Flouride	mg/L	24	0.49	0.01	0.50	0.09	0.18	0.03	1.910	1.792
Iron	mg/L	24	0.20	0.30	0.50	0.31	0.05	0.00	3.220	9.124
Potassium	mg/L	24	20.00	20.00	40.00	28.12	5.86	34.37	0.466	-0.341
BOD_5	mg/L	24	0.90	0.50	1.40	0.95	0.28	0.07	0.089	-1.176
T. Hardness	^{0}dH	24	11.40	3.20	14.60	8.81	3.17	10.09	0.435	-0.565
Calcium	mg/L	24	81.39	22.85	104.24	62.95	22.68	514.74	0.435	-0.565
Magnesium	mg/L	24	48.79	13.70	62.49	37.73	13.60	184.98	0.436	-0.565

N: Number of Observations, Min: Minimum, Max: Maximum, SD: Standard Deviation in the table.

Table 2. Kaiser-Meyer-Olkin and Bartlett's test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.627
Bartlett's Test of Sphericity	Approximately Chi-Square	705.118
	df	66.000
	Sig.	0.000

When the coefficients of skewness related to the physicochemical variables of the fountain water samples were examined, it was determined that iron (3.220) was the variable with the furthest distribution from the normal distribution. It is seen that iron is followed by nitrite (2.422), flouride (1.910), nitrate (1.355), chloride (0.678), ammonium (0.551), potassium (0.466), magnesium (0.436), total hardness (0.435), calcium (0.435), pH (-0.270) and BOD_5 (0.089), respectively. In this research, physicochemical variables that showed the closest to normal distribution and the furthest distribution according to the coefficient of skewness were BOD_5 (0.089) and iron (3.220), respectively (Table 1). In addition, the positive skewness coefficients obtained by the majority of physicochemical fountain water characteristics reveal that the majority of the data have values above the average.

Kaiser-Meyer-Olkin test and Bartlett's test findings are given in Table 2. The Kaiser-Meyer-Olkin test and Bartlett's test measures the strength of the relationship between variables. The Kaiser-Meyer-Olkin test predicts that the sample should be larger than 0.5 in order to perform a satisfactory factor analysis. If the KMO test value is less than 0.50, factor analysis cannot be continued. In the Barlett's test of sphericity, sig should be <0.05. If it is below 0.5, it is rejected. This means that the correlation matrix is not an identical matrix. If Bartlett's test value in the table is P<0.001, this indicates that we can move forward. In this research, KMO test value was determined as 0.627 (Table 2). It is sufficient to obtain a value above 0.5 for a healthy factor analysis. According to the Bartlett's test result, the P value was determined as 0.000 in this research (Table 2). In this direction, it is possible to proceed in a healthy way. Accordingly, the KMO test value being 0.627 and the Bartlett's test giving a significant result demonstrates that the sample size in the research was sufficient and the data set is appropriate for factor analysis.

The principal component analysis findings of the 12 variables examined in the fountain water samples taken from 6 selected stations in Sivas province are presented in Fig. 1. Looking at the scree plot graph, it can be observed that the slope does not change very much after the 4th main component. It is concluded that it can be explained in a 4-factor structure, overlapping with the results in principal components analysis.

Total variance explained values of components are presented in Table 3. The data set used in this research can be reduced to a 4-factor structure with an

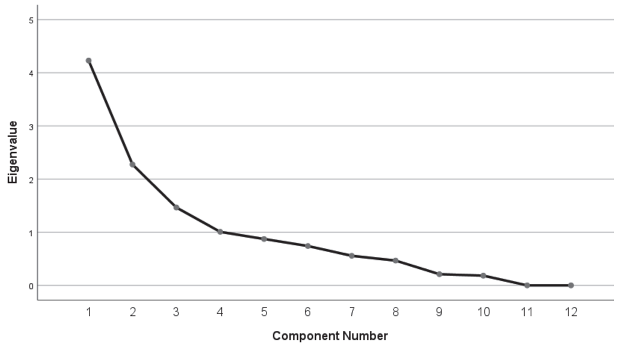

Fig. 1. Slope line graph.

Eigenvalue greater than 1. Factor 1 explains 35.24% of the total variance. Following this, 2nd factor explains 18.94% of the total variance, 3rd factor 12.20%, and 4th factor 8.391%, respectively. The total explanation rate of the factors model is 74.79% (Table 3). Factor analysis is used to create new common factor structures by explaining the data with high correlation with each other with less data independent of each other. Factors express the importance of basic components. The highest factor provides the highest contribution [7]. Four different components determined in the present Research explain 74.79% of the total variance (Table 3). It can be concluded that collecting most of the variables in the 1st and 2nd factors explains 53.609% of the total variance of these two factors, and the effect of the physicochemical variables studied is mostly characterized by the 1st and 2nd factors in the research area. The first factor constituted 33,536% of the cumulative variance in the data set. In the first factor, the largest loads belong to the variables total hardness (0.979*), calcium (0.979*), magnesium (0.979*), chloride (0.759*) and pH (-0.633**), respectively. Total hardness, calcium and magnesium have the highest positive effect. After these, the variable with the highest positive effect is chloride. The pH has a moderate and negative effect (Table 4). In the first factor, the high total hardness, calcium, magnesium, chloride and pH loads are due to the fact that the geological structure of the region has a karstic character.

The second factor constituted 20.073% of the cumulative variance (Table 3). In the second factor, the largest loads are fluoride (0.849*), potassium (0.694**), nitrite (0.687**) and iron (0.548**), respectively. Significantly, fluoride has a very strong and positive effect. Nitrite, iron and potassium components also have a moderate and positive effect (Table 4). Fluoride is generally found in natural waters at low levels. However, volcanic rocks, mica minerals, fertilizers and thermal springs can cause high fluoride levels in natural waters [8]. Fluoride is required to be present in a certain amount in drinking water. When fluoride is taken in the appropriate amount, it prevents tooth decay and helps bone development. However, exposure to excessive amounts of fluoride for a long time leads to fluorine poisoning and skeletal problems [9, 10]. Considering

Table 3. Total variance explained values of components.

C	Initial Eigenvalues Range			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	T	%V	C%	T	%V	C%	T	%V	C%
1	4.229	35.245	35.245	4.229	35.245	35.245	4.024	33.536	33.536
2	2.274	18.948	54.193	2.274	18.948	54.193	2.409	20.073	53.609
3	1.465	12.206	66.399	1.465	12.206	66.399	1.443	12.022	65.632
4	1.007	8.391	74.790	1.007	8.391	74.790	1.099	9.158	74.790

C: Component, T: Total, %V: % of Variance, C%: Cumulative % in the table.

Table 4. Factor loading matrix after varimax rotation.

Variables	Units	Factor 1	Factor 2	Factor 3	Factor 4
pH	pH unit	-0.633**			
Ammonium	mg/L			-0.654**	
Nitrite	mg/L		0.687**		
Nitrate	mg/L				0.904*
Chloride	mg/L	0.759*			
Flouride	mg/L		0.849*		
Iron	mg/L		0.548**		
Potassium	mg/L		0.694**		
BOD_5	mg/L			0.808*	
Total Hardness	^{0}dH	0.979*			
Calcium	mg/L	0.979*			
Magnesium	mg/L	0.979*			

The asterisks notations in the table *: Strong (F>0.75); **: Moderate (0.50<F<0.75); ***: Weak (0.30<F<0.50) shows the significance level of the factors obtained as a result of factor analysis.

both the benefit and the harm, the amount of fluoride in drinking water is very important. Table 2 indicates that the average fluoride levels of fountain water samples in the research area are below 0.5 mg/L, which is the lower limit of WHO [11], and they have levels that cause dental caries. This situation can have negative consequences for tooth development and health. Potassium passes into water by some geochemical processes. Potassium in drinking water is rarely found at levels that may cause disquiet for people. Whilst potassium can cause some health impacts in sensitive persons, it intake from drinking water is far under the grade at which side health impacts can emerge [11]. Nitrite is a medium product in biological oxidation from ammonium to nitrate. Nitrite levels are very low in natural waters. However, nitrite can reach high levels where there is organic contamination and the amount of dissolved oxygen is low. Some nitrite can be found naturally in the environments where nitrate is present, depending on the conditions [12]. The presence of nitrite at very low levels in Sivas fountain waters may be an indicator of organic contamination.

The third factor constituted 12.022% of the cumulative variance (Table 3). In the third factor, the largest loads are BOD_5 (0.808*) and ammonium (-0.654**), respectively. Significantly, BOD_5 has been found to have a very strong and positive effect, while ammonium has a moderate and negative effect (Table 4). The biochemical oxygen demand used to determine the amount of organic substances that can be degraded by microorganisms in water indicates the amount of oxygen required for the decomposition of organic pollutants. The amount of organic matter can increase with intensive use of fertilizers and sewage water. BOD_5 is one of the most used variables in determination of pollution in waters. A low BOD_5 value indicates that the water is clean or that microorganisms do not consume the organic matter in the water [13]. In drinking water, the major resource of ammonium originates from organic substances in the water. Ammonium concentrations in drinking water likely indicate fresh faecal contamination and a health hazard [10]. Ammonium and BOD_5 components are indicative of anthropogenic effects on water quality. The fountain waters of Sivas province are not exposed to large amounts of organic matter from agricultural and domestic areas.

The fourth factor constituted 9.158% of the cumulative variance (Table 3). The fourth factor includes only nitrate, and nitrate has a positive and strong effect (Table 4). Nitrate, nitrite and ammonium are substances that commonly occur in the natural nitrogen cycle. Ammonium is easily converted to nitrite first and then to nitrate under suitable reaction conditions by biological oxidation. When drinking water contains high levels of ammonium, it easily turns into nitrate. Nitrate is a major toxicological disquiet as it is related in the output of nitrite and nitrosamine [14]. The presence of nitrate in drinking water indicates an old contamination [10]. Consuming water with high nitrate levels for a long time can cause poisonings [15]. The nitrate values analyzed from the fountain water samples of Sivas province remained well below the maximum allowable value in EPA [16] and WHO [11].

The similarity diagram obtained as a result of the hierarchical cluster analysis made to determine the similarity between the stations is given in Fig. 2. Annual arithmetic mean values were used in cluster analysis applications of 12 physicochemical variables. Since the similarities between the 3rd Station, 5th Station, 2nd Station and 1st Station and 6th Station are very strong, these profiles form groups at a distance of one unit. Stations 1 and 6 were included in the group of stations 3, 5, and 2 at a distance of 8 units. Station 4 is included in the other stations at a distance of 25 units. When the dendrogram showing the cluster analysis results is examined, it is seen that the variables of fountain water in stations are classified in two well-differentiated clusters. According to the classifications in the similarity dendrogram, the first cluster consists of stations 1, 2, 3, 5 and 6, while the second cluster consists of only station 4 (Fig. 2). This situation shows that the 1st, 2nd, 3rd, 5th, and 6th stations are close and similar to each other in terms of values of physicochemical variables. It indicates that the 4th station is different from the 1st, 2nd, 3rd, 5th and 6th stations in terms of values of physicochemical variables. The highest chloride, total hardness, calcium and magnesium values were determined at the 4th station in winter. On the other hand, the highest pH value was measured in the autumn season at the 5th station and the highest nitrate value in the spring season at the 2nd station. In the evaluations within the cluster, the sub-clusters are perceived differently in the similarity dendrogram. Accordingly, the sub-clusters of the first cluster are divided into two different groups in the cluster evaluation. The first group includes 2nd, 3rd and 5th stations. The second group includes 1st and 6th stations. In the lower cluster of the second cluster, there is only 4th station. The main reason for the difference between the 4th station and the other stations is thought to be due to that this fountain is connected to the fresh water used in the university campus, not the province water supplies.

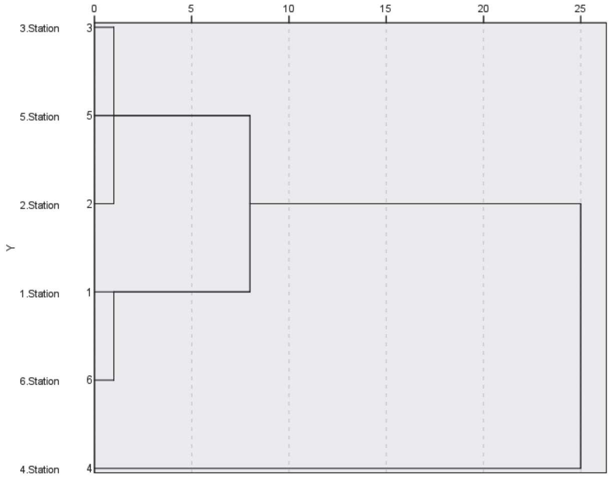

Fig. 2. Similarity diagram.

Physicochemical variables of fountain water revealed a significant relationship with a strong proximity to each other in Sivas. (Table 5). According to correlation analysis results, 11 out of 78 correlation pairs between physicochemical fountains water variables were found to be statistically significant ($P<0.01$; $P<0.05$). The greatest positive correlation was found between total hardness, calcium and magnesium (1.000), while the highest negative correlation was found between pH, total hardness, calcium, and magnesium (-0.606). Average pH value in the research area was determined as 8.13 Table 1. The pH varied from 7.56 to 8.65 with maximum value 8.65 observed in autumn from Station 5 and showed strong negative correlation with total hardness ($r = -0.606$, $P<0,01$); pH and calcium ($r = -0.606$, $P<0.01$); pH and magnesium ($r = -0.606$, $P<0.01$) for the six sampling stations. The pH showed significant correlations with three variables i.e. total hardness, calcium and magnesium at ($P<0.001$) level in the negative direction. The relationship of pH with other physicochemical variables was found to be statistically insignificant (Table 5). The pH value can generally be associated with the geological structure of the region. The pH value has never been measured in an acidic structure at the stations. In other words, the pH values analyzed samples have always been measured above 7.00 in the research area. Accordingly, the fountain waters of Sivas province were found to be slightly alkaline. This feature of the slightly alkaline fountain waters is generally due to the presence of bicarbonate ions. The findings about pH obtained were found to be similar to the values obtained by some researchers [17-19], who conducted research on fountain water in different provinces. EPA [16] recommends that the accepted drinking water standard for pH should be between 6.5 and 9.5. These pH values indicate that the public fountain waters in Sivas can be drunk in terms of pH.

Other physicochemical variables did not have a significant statistical effect on ammonium (Table 5).

Table 5. Correlation matrix of fountain water physicochemical variables.

Variables	pH	NH_4	NO_2	NO_3	Cl	F	Fe	K	BOD_5	T. H	Ca	Mg
pH	1											
NH_4	-0.166	1										
NO_2	0.321	0.228	1									
NO_3	0.145	-0.228	0.081	1								
Cl	-0.353	0.100	-0.029	-0.196	1							
F	0.111	0.346	0.507*	-0.189	0.173	1						
Fe	0.216	0.078	0.342	-0.012	0.117	0.270	1					
K	0.239	0.328	0.233	0.167	-0.042	0.536**	0.230	1				
BOD_5	0.252	-0.266	-0.023	0.100	0.042	0.162	0.109	0.033	1			
TH	-0.606**	0.129	-0.196	-0.116	0.670**	-0.046	-0.195	-0.306	0.170	1		
Ca	-0.606**	0.129	-0.196	-0.116	0.670**	-0.045	-0.195	-0.306	0.170	1.000**	1	
Mg	-0.606**	0.129	-0.196	-0.116	0.670**	-0.046	-0.195	-0.306	0.170	1.000**	1.000**	1

NH_4: Ammonium, NO_2: Nitrite, NO_3: Nitrate, Cl: Chloride, F: Flouride, Fe: Iron, K: Potassium, BOD_5: Biochemical Oxygen Demand, TH: Total Hardness, Ca: Calcium, Mg: Magnesium, *: Correlation is significant at the 0.05 level, **: Correlation is significant at the 0.01 level in the table.

It was determined that the ammonium values of the fountain water samples varied between 0.00-0.16 mg/L with an average value of 0.06 mg/L in the research area. However, it has been observed that the ammonium values determined in fountain waters by Şekerci [20] in Erzurum, Gümüş et al. [18] in Karaman and Çankaya et al. [21] in Trabzon were quite similar to the findings of this research. EPA [16] reports that ammonium in drinking water should not exceed 0.30 mg/L and that ammonium may be an indicator of possible bacteria, sewage and animal waste contamination. It has been observed that the ammonium values determined in all samples were lower than the maximum allowed value in EPA [16]. While the relationship between nitrite and fluoride ($r = 0.507$; $P<0.05$) was statistically positive and significant, the relationship between nitrite and other physicochemical variables was found to be insignificant (Table 5). Nitrite values varied between 0.00-0.01 mg/L for the six sampling stations. The highest nitrite values were determined with 0.01 mg/L at stations 1 and 2 in summer. During the research period, nitrite was not determined at the 3rd, 4th, 5th and 6th stations. Nitrite levels were determined below the parametric value of 0.50 mg/L proposed for drinking water by the EPA [16]. The nitrite levels determined in this research were found to be similar to the nitrite levels recorded by Şekerci [20] from Erzurum province and Gümüş et al. [18] from Karaman province and in fountain waters. No significant effect of other physicochemical variables on nitrate was observed according to the correlation test results given in Table 5. The nitrate levels detected in this research are similar to the nitrate levels recorded by Bilgin [22] from Niğde and Şekerci [20] from Erzurum. The nitrate level in fountain water samples ranges between 2.30-11.00 mg/L, and it was determined to be below the highest value of 50 mg/L recommended by EPA [16] and WHO [11]. Accordingly, the ammonium, nitrite and nitrate values of Sivas fountain waters do not pose any risk to public health.

Chloride varied from 4.00 to 14.00 mg/L with maximum value 14.00 mg/L determined in winter from Station 4 and demonstrated strong positive correlation with total hardness ($r = -0.606$, $P<0,01$); chloride and calcium ($r = -0.606$, $P<0.01$); chloride and magnessium ($r = -0.606$, $P<0.01$). Chloride showed significant correlations with three variables i.e. total hardness, calcium and magnesium at ($P<0.001$) level in the positive direction (Table 5). The correlation between chloride and calcium ($r = 0.612$) determined by Şekerci [20] in the fountain waters of Erzurum province, supports the correlation result obtained in this research ($r = 0.670$). Similarly, the correlation ($r = 0.623$) determined by Şekerci [20] between chloride and magnesium is quite compatible with the correlation result obtained in this research ($r =0.670$). The average chloride value was found as 8.16 mg/L in Sivas province (Table 1). The average chloride value in Sivas was found to be lower than the average chloride value in the fountain waters of Erzurum, Karaman and Yozgat provinces [18-20]. Total hardness levels obtained in this research were similar to the total hardness levels reported by Bilgin [22] from Niğde province. All chloride values of the public fountains water samples analyzed in this research were found below the 250 mg/L limit recommended by EPA [16] and WHO [11]. This indicates that the chloride presence in Sivas province fountain waters does not pose a danger to the public health.

Fluoride was found to be significantly correlated with nitrite and potassium at ($P<0.05$) level in the positive direction (Table 5). The relationship of fluoride with other physicochemical variables except for nitrite and potassium was found to be statistically insignificant. The fluoride content of the fountain water samples varied from 0.01 to 0.50 mg/L, with an average value of 0.09 mg/L for the six sampling stations. This result is in accordance with the content of fluoride detected by Gümüş et al. [18] in Karaman and Iritas et al. [19] in Yozgat for fountain waters. Demer and Memiş [9] reported the fluoride values in the drinking water of Isparta between 0.14-1.13 mg/L and these values are considerably higher than the fluoride values in the fountain water of Sivas province. WHO [11] states that the fluoride in water should not exceed the highest directive value of 1.5 mg/L for drinking water. In the research area, it was observed that the content of fluoride measured in each fountain water sample did not exceed the maximum guideline value suggested by WHO [11]. Low and high fluoride levels in drinking water threaten human health [9, 11]. Therefore, the fluoride level should be evaluated correctly in drinking water. At the same time, WHO [11] recommends fluoride guideline values in drinking water ranging from 0.5 mg/L to 1.5 mg/L to prevent tooth deterioration. These optimal fluoride guideline values can prevent dental caries and also reduce the risk of dental fluorosis. Dissanayake [23] reports that fluoride causes tooth decay when it falls under 0.5 mg/L. The average fluoride value of fountain water samples in Sivas province was found to be significantly lower than the optimal lower limit recommended by Dissanayake [23] and WHO [11] for dental health. In this case, it indicates that the local people, who consume continuously fountain water in Sivas as drinking water, will suffer from tooth decay.

The highest iron level was determined with 0.5 mg/L at stations 2 and 3 in summer. In this research, a statistically significant correlation was not observed between iron and other physicochemical variables (Table 5). Şekerci [20] recorded the highest iron content of fountain water samples in Erzurum province as 2.42 mg/L. Generally, iron levels below 0.3 mg/L do not have a distinctive taste. However, blurring and color may occur. WHO [11] does not proposed a health-related guideline value for iron in drinking water.

Positive and moderate significant correlation was observed between potassium and fluoride at ($P<0.01$) level (Table 5). Other physicochemical variables did not have a significant effect on potassium. Potassium level ranged from 20.00 to 40.00 mg/L with an average value of 28.12 mg/L for the six sampling stations. The highest potassium level was determined with 40 mg/L at station 2 in spring and summer. Şekerci [20] recorded the highest amount of potassium in the fountain waters of Erzurum province as 40.86 mg/L, which is quite similar to the highest amount of potassium determined in Sivas. It has been reported by WHO [11] that it is not necessary to give a health-related guideline value for potassium in drinking water.

The relationship of BOD_5 with other physicochemical variables was observed to be statistically insignificant (Table 5). While the lowest BOD_5 value was detected in spring at Station 1 with 0.5 mg/L, the highest BOD_5 value was measured at Station 2 in autumn-winter seasons and at Station 6 in summer with 1.40 mg/L. It has been determined that the BOD_5 values determined in the research area do not exceed the guideline value proposed by TWRHC [24] as 5.00 mg/L. Accordingly, BOD_5 values do not pose a problem for the public health in Sivas.

Total hardness ranged between 3.20-14.60 ^{0}dH and Station 4 recorded in winter the highest total hardness value (14.60 ^{0}dH); total hardness demonstrated very strong positive correlation with calcium ($r = 1.000$, $P<0.01$); total hardness and magnesium ($r = 1.000$, $P<0.01$) in the research area. This situation is due to the hardness of the water mostly consisting of calcium and magnesium ions and the geological structure of the research area. Total hardness is an important quality feature for drinking water. According to the German hardness grade, waters 0-4 ^{0}dH (very soft), 4-8 ^{0}dH (soft), 8-12 ^{0}dH (medium hard), 12-30 ^{0}dH (hard), 30-50 ^{0}dH (very hard) and >50 ^{0}dH (unusually hard) are classified by Klee [25]. The average total hardness value was found as 8.81 ^{0}dH in the research area. When the average total hardness value determined in Sivas is classified according to Klee [25], it was found in the "Medium Hard" class. Medium hard waters are water that have the ideal hardness for drinking. Total hardness levels in fountain waters obtained in the present research were lower than those obtained by Gümüş et al. [18] from Karaman province and Koçak and Güner [26] from Erzurum province. Total hardness levels obtained in this research were similar to the total hardness levels reported by Yelekçi et al. [17] from Kilis province and Bilgin [22] from Niğde province.

A very strong and significant positive correlation was observed between calcium and magnesium at ($P<0.01$) level (Table 5). Şekerci [20] and Hiu et al. [27] showed that there is a very strong correlation ($r = 0.911$, $r = 0.93$) between calcium and magnesium in the drinking waters of Erzurum and Lianhuashan, and it supports the correlation result obtained in this research ($r = 1.000$). The most effective ions that gives water hardness feature are calcium and magnesium. Therefore, it has been observed that the calcium and magnesium values of the 4th station fountain, which has the highest total hardness value, are also the highest in this research. The human body needs approximately 1 gram of calcium per day. The consumption of drinking water whose calcium level exceeds 1000 mg/L causes arteriosclerosis and kidney stones to form [28]. Magnesium has a preventive effect on problems related to bones, cardiovascular system, diabetes and other functions [29]. WHO [11] did not recommend any limits for calcium, magnesium and total hardness.

Conclusions

Multivariate data analysis methods were used to commentate the drinking water quality of Sivas province public fountain waters in this research. Cluster analysis created two main clusters for six sampling points according to fountainp water sampling. Principal component analysis and factor analysis found four different water quality factors and the effect size of these factors on variance. It shows that the use of multivariate statistical analysis methods such as principal component analysis, factor analysis and cluster analysis may be appropriate for interpreting water quality data and understanding changes. The results obtained indicate that there is no significant input that could damage Sivas fountain waters. As a result, it has been determined that the quality of public fountain water in Sivas has appropriate international criteria, especially as drinking water. For the average fluoride amount below the desired lower limit values, it is recommended to add fluoride to Sivas province public fountain water with appropriate amounts and methods. Because of the significance of consuming drinking water, the quality of Sivas province fountain water should be monitored strictly and regularly. The results of this research will contribute to the quality level database of Sivas province fountain water and will be a reference point for future changes.

Conflict of Interest

No conflict of interest was declared by the author.

References

1. SAHANKAYA E. Sivas water structures. Erciyes University, Institute of Social Sciences, History of Art Department, Master Thesis, Turkey, 112, **2014**.
2. ANONYMOUS. Sivas province environmental status report in 2018. Sivas Governorate, Provincial Directorate of Environment and Urbanization, 135, **2019**.
3. TURKSTAT. The results of address based population registration system in 2019. Turkish Statistical Institute, http://tuik.gov.tr/PreTablo.do?alt_id=1059, Date of access: 26.03.**2020**.
4. KARAGOZ N., KOCOGLU G. Sivas population health survey household situation in 1997. Cumhuriyet Medical Journal, **41** (2), 263, **2019**.
5. DIRICAN S. A preliminary correlation and regression study on drinking water quality of Suşehri district in Turkey. Romanian Biotechnological Letters, **24** (2), 201, **2019**.
6. KAR M., LEBLEBICI Z. Using multivariate statistical techniques to evaluate the quality of water reservoirs: Yamula dam lake case study. Afyon Kocatepe University Journal of Science and Engineering, **20**, 189, **2020**.
7. UNCUMUSAOGLU A.A., MUTLU E. Water quality assessment in Karaboğaz Stream Basin (Turkey) from a multi-statistical perspective. Polish Journal of Environmental Studies, **30** (5), 4747, **2021**.
8. ONIPE T., EDOKPAYI J.N., ODIYO J.O. Geochemical characterization and assessment of fluoride sources in groundwater of Siloam area, Limpopo province, South Africa. Scientific Reports, **11**, 1, **2021**.
9. DEMER S.A., MEMIS U. Investigation of different fluoride contents of drinking waters in Isparta city center. Ekoloji, **20** (79), 77, **2011**.
10. TULUK B., ORHAN F.K., KAŞALI K. An investigation on physical, chemical and microbiological quality of drinking water in Erzurum city. Journal of Turgut Ozal Medical Center, **24** (1), 25, **2017**.
11. WHO. Guidelines for drinking water quality: fourth edition incorporating the first addendum. World Health Organization, Geneva, Switzerland, 541, **2017**.
12. DEY S., HARIPAVAN N., BASHA S.R., BABU G.V. Removal of ammonia and nitrates from contaminated water by using solid waste bio-adsorbents. Current Research in Chemical Biology, **1**, 1, **2021**.
13. AL-SULAIMAN A.M., KHUDAIR B.H. Correlation between BOD_5 and COD for Al- Diwaniyah wastewater treatment plants to obtain the biodigrability indices. Pakistan Journal of Biotechnology, **15** (2), 423, **2018**.
14. CAYLA E., TOKAR M. Investigating chemical and microbiological contaminants in drinking water of Çankırı province, Turkey. Environmental Earth Sciences, **67**, 2015, **2012**.
15. CAVUS A., ATICI A.A., SEN F. Investigation of water quality criteria of drinking waters in center of Van, Turkey. Yüzüncü Yıl University Journal of Agricultural Sciences, **27** (3), 326, **2017**.
16. EPA. Drinking water parameters - microbiological, chemical and indicator parameters in the 2014, Drinking Water Regulations 2014. Environmental Protection Agency, Johnstown Castle Estate, Wexford, Ireland, 9, **2014**.
17. YELEKCI S., ACEMIOGLU B., ACI H. Investigation of the usability of the drinking water of Kilis province. Research Journal of Biology Sciences, **5** (2), 77, **2012**.
18. GUMUS N.E., KARATAS M., AKKOZ C. Chemical and bacteriological properties of fresh water fountains of Karaman province. Journal of Applied Biological Sciences, **7** (1), 72, **2013**.
19. IRITAS S.B., TURKSOY V.A., DENIZ S., KOCOGLU S., KIRAT G., DEMIRKESEN A.C., BABA A. A quality assessment of public water fountains and relation to human health: a case study from Yozgat, Turkey. Water and Environment Journal, **33**, 518, **2018**.
20. SEKERCI P. Microbiological, physical, chemical analysis and molecular typing of E. coli isolates from fountain waters, Erzurum. Atatürk University, Graduate School of Natural and Applied Science, Department of Food Engineering, Master Thesis, Turkey, 85, **2012**.
21. CANKAYA S., TOPBAS M., YILMAZ A.Y., UCUNCU Ş.Y., KARAKULLUKCU S., KOLAYLI C.C., DILAVER I., ACAR G., PARLAK B., ŞAHIN K., HAMZAOGLU K., BOLUKBAS C., CAN G., BEYHUN E. The physical, chemical and microbiological analysis of public fountains in Trabzon. Turkish Bulletin of Hygiene and Experimental Biology, **74** (1), 21, **2017**.
22. BILGIN M. An investigation on the physical, chemical and bacteriological properties of the drinking waters in Niğde city. Niğde University, Institute of Science and Technology, Master Thesis, Turkey, 54, **2003**.

23. DISSANAYAKE C.B. The fluoride problem in the ground water of Sri Lanka - environmental management and health. International Journal of Environmental Studies, **38** (2), 137, **1991**.
24. TWRHC. Turkish waters regulation for human consumption. Official Journal of Turkey Republic, No: 25730, pp. 32, 17 February **2005**.
25. KLEE O. Wasser untersuchen: einfache analysenmethoden und beurteilungskriterien. 1. Auflage, Quelle & Meyer, Wiesbaden, 230, **1990**.
26. KOCAK O., GUNER A. Chemical, physical and microbiological qualities of tap water in Erzurum City. Atatürk University Journal of Veterinary Sciences, **4** (1), 9, **2009**.
27. HUI T., XIUJUAN L., QIFA S., QIANG L., ZHUANG K., YAN G. Evaluation of drinking water quality using the water quality index (WQI), the synthetic pollution index (SPI) and geospatial tools in Lianhuashan District, China. Polish Journal of Environmental Studies, **30** (1), 141, **2021**.
28. MITRA P., PAL D.K., DAS M. Does quality of drinking water matter in kidney stone disease: a study in West Bengal, India. Investigative and Clinical Urology, **59** (3), 158, **2018**.
29. ALAWI A.A., MAJONI S.W., FALHAMMAR H. Magnesium and human health: perspectives and research directions. International Journal of Endocrinology, 1, **2018**.