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A Statistical Assessment of Drinking Water Quality: A Case Study of Doburca Treatment Plant, Bursa

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Abstract: In order to provide and maintain urban health standards, assessing the quality of drinking water is an essential step. As a result of different pollutant factors (climate, heavy metals, vegetation, human activities, etc.), it is inevitable that the quality of water resources decreases day by day. In this study, the data of 21 water samples taken between January 2021 and June 2021 from the water drinking facility providing drinking water to Bursa were examined. Firstly, the strength and direction of the relationship between 10 different parameters (electrical conductivity (EC), copper (Cu), nickel (Ni), nitrate (NO_3^-), arsenic (As), iron (Fe), total dissolved substances (TDS), total alkalinity (TA), total hardness (TH) and dissolved oxygen (DO)) were evaluated with the help of relation analysis, water quality index, and polynomial curve fitting. The relationship of the parameters that do not have a linear correlation was also interpreted and finally, as a result of using the weighted arithmetic water quality index (WAWQI), it was determined that the potability of the water quality in the allocated water reservoir was at the 'excellent' level and fulfills the requirements.

Keywords: Treatment plants, Correlation analysis, Surface water, Water quality index

İçme Suyu Kalitesinin İstatistiksel Olarak Değerlendirmesi: Bursa Doburca Arıtma Tesisi Örneği

Öz: Kentsel sağlık standartlarını sağlamak ve bu standartları sürdürebilmek için içme sularının kalitesini değerlendirmek öncelikli adımdır. Farklı kirletici faktörlerin (iklim, ağır metaller, bitki örtüsü, beşeri faaliyetler vs.) su kaynaklarını tehdit etmesi neticesinde günden güne kalitenin düşmesi kaçınılmaz olmaktadır. Bu bağlamda, ülkemizin dördüncü büyük şehri olan Bursa'ya içme suyu sağlayan tesisin Ocak 2021 ile Haziran 2021 tarihleri arasında alınan 21 su numunesine ilişkin verileri, çeşitli ilişki analizi yöntemiyle incelenmiştir. Öncelikle, değerlendirilmek üzere olan 10 farklı (elektrik iletkenliği (EC), bakır (Cu), nikel (Ni), nitrat (NO_3^-), arsenik (As), demir (Fe), toplam çözünmüş maddeler (TDS), toplam alkalinite (TA), toplam sertlik (TH) ve çözünmüş oksijen (DO)) parametre arasındaki ilişkinin gücü ve yönü ilişki analizi, su kalite indeksi ve polinom eğri uydurma yöntemine tabi tutularak irdelenmiştir. Doğrusal korelasyon ilişki bulunmayan parametrelerin ilişkisi yorumlanmış ve son olarak ağırlıklı aritmetik su kalitesi indeksi (WAWQI) neticesinde tahsis edilen su deposundaki su kalitesinin içilebilirliğinin 'mükemmel' seviyede olduğu ve gereklilikleri karşıladığı tespit edilmiştir.

Anahtar kelimeler: Arıtma Tesisleri, Korelasyon analizi, Yüzeysel su, Su kalitesi indeksi

1. Introduction

Water is an indispensable building block of human life. It is a source for life that covers three quarter of the world's surface, and constitute 70% of the body mass. However, only one percent of the total (1.4 billion km^3) water reserves on Earth is fresh and suitable for direct use while the drinking water constitutes only one third of the fresh water resources [1]. Although a relatively small portion of available water is used for drinking purposes, finding a reliable and suitable source of so-called 'clean water' fitting for the water quality codes suggested by World Health Organization (WHO) is a hard task. By far, access to the clean water is recognized as a fundamental right for anyone [2]. But, about 780 million people around the world do not have access to sufficient clean water. In this respect, many people have low life standards, and get sick very often due to the consumption of water that does not meet the expectations.

The water pollution control and regulation is one of the most important policy agendas [3]. Yet, potable waters are adversely affected by pollutants from domestic, industrial, and agricultural activities. More precisely, the discharge

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of industrial and domestic wastes into the surface waters, the use of pesticides, and pollution caused by the sea vessels are the main factors that reduce water quality [4,5]. In this respect, the water pollutants can be categorized as organic, inorganic, and microbiologic type [6]. However, the inorganic pollutants have the largest share in contamination of the drinking water. These pollutants are usually formed by the discharge of industrial processes and waters into the waterways that are mainly composed of metals, salts, mineral acids and minerals [7]. These substances, are very likely to mix into the drinking water, and not only increase the acidity and salinity level of the water but also increase the water toxicity. As a result, this can cause serious damage to the human and animal health and even be fatal due to the presence of heavy metals with high concentration, toxicity, and carcinogenic effects in humans [8]. Studies show that the accumulation of *Pb*, *Zn*, *Hg*, *Ni*, *As* and *Cu* in drinking water has increased in the last 50 years and therefore threatens human health [9].

By far, a number of tools and codes have been developed to control and evaluate the water pollutants. These procedures include various analysis on different parameters, e.g. heavy metals, pH, turbidity, and total dissolved substances [3, 10]. However, if the concentration of the parameters does not cross the predefined limits (e.g. those suggested by World Health Organization, WHO), the compliance of the water with the drinking water standards is approved for consumption. In this respect, there are various water quality indices that evaluate the drinking water quality, enabling researchers to agree on important principals. These indexes combine the data obtained from more than one water quality parameter in a mathematical equation that ranks the nature of water bodies with numbers and produces a drinking water quality index [11]. Water quality indices (WQI) were first developed by Horton in 1965 to evaluate water quality with the help of 10 commonly used water quality parameters. The method was later updated by different experts with the help of different water quality parameters. In a WQI, the parameters to be used are initially selected and their correspondence functionality are determined based on the framework of the water quality code. Afterwards, the WQI is calculated based on predefined equation(s) later to be evaluated for making decisions [12]. As different results have been reported for by national and international organizations, many WQIs has been developed around the world to alternate each other. Likewise, Weighted Arithmetic Water Quality Index (WAWQI), the National Sanitation Foundation Water Quality Index (NSFWQI), the Canadian Council of Environment Ministers' Water Quality Index (CCME WQI), and the Oregon Water Quality Index (OWQI) are the most well-known indices. WAWQI, is one of these indexes, that provides the opportunity to obtain results with fewer parameters, especially compared to the other water quality indexes [13]. In the study of Anyanwu et al. [14] used the WAWQI, to evaluate the drinking water quality of the Ikru river in Nigeria. For this, 13 parameters including temperature, pH, electrical conductivity, dissolved oxygen, total dissolved solids, chemical oxygen demand, nitrate, alkalinity, phosphate, sulphate, chloride, and calcium were evaluated among the physico-chemical parameters of the river. It was concluded that the water samples from one of the stations is not suitable for drinking. In the study of Ochuko et al. [11] used NSFWQI to evaluate the water samples taken from four different settlements between January 2011 and December 2011. It is reported that the NSFWQI of the data taken from the urban settlement area has a much lower NSFWQI values than the data in the rural settlement area. In conclusion, the NSFWQI showed that the rural communities of Obikwele and Osemele recorded a higher NSFWQI of 58.08 and 54.92, respectively, compared to 42.80 and 46.30 recorded in the urban communities of Kwale and Ashaka. In the study of Al-Ani [15], water samples were taken from seven different stations to evaluate the water quality in the Al-Hilla River located at the south of Baghdad with the help of the WAWQI. In the study, eight different parameters including turbidity, TDS, dissolved oxygen, hydrogen ion concentration, EC, chlorides, alkalinity and biological oxygen demand were examined and the calculated WAWQI rates, indicated that the river water is not suitable for drinking.

By far, correlation analysis can be considered as one of the most popular tools in evaluation of the link between water quality parameters. For instance, in the study of Tong et al. [16] examined the relationship between drinking water parameters in the Lhasa region in China with help of the correlations coefficient. Conducted analysis showed that, the correlation between the pairs of *Se-Cd*; *Se-Pb*; *Pb-Cd*; *Ni-Cu*; *Co-Cu*; and *Ni-Co* is respectively as 0.6147 ($p<0.01$), 0.6713 ($p<0.01$), 0.5680 ($p<0.01$), 0.6757 ($p<0.01$), 0.5322 ($p<0.01$), and 0.9239 ($p<0.01$). It is concluded that the concentration of the *Se*, *Cd*, and *Pb* in the samples may be originated from the same source; while the concentration of *Ni*, *Co* and *Cu* in the samples may be of the same source. In the study of Heydari et al. [17], chemical and statistical correlation and regression analyses were performed on drinking water samples from five sites (21 sampling wells) located in hot and dry climate at Kashan city located in central Iran. Twelve parameters including pH, EC, TDS, total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), sulphate (SO_4^{2-}), chloride (Cl^-), nitrate (NO_3^-), sodium (Na^+), potassium (K^+) and fluoride (F^-) were evaluated in the study during October 2006 to May 2007 (25-30 °C). The obtained results indicated to the dominance of *NaCl* (WHO), while there existed strong positive correlations between TDS - EC (r:0.99), and Ca^{+2} - TH (r:0.95). It was also concluded that the systematic calculations of correlation coefficients between water parameters and regression analysis provide a useful tool for rapid monitoring of water quality.

In this study, the quality of drinking water provided to the people of Bursa by the Doburca Drinking Water Treatment Plant was analysed in terms of 10 parameters including electrical conductivity (EC), copper (Cu), nickel (Ni), nitrate (NO_3^-) arsenic (As), iron (Fe), total dissolved substances (TDS), total alkalinity (TA), total hardness (TH) and dissolved oxygen (DO) were evaluated as a result of weekly water samples taken between January 2021 and June 2021. Pearson's correlation coefficient was used to represent the relationship between pairs of parameters, and the pairs with a very strong relationship and low linear correlation were interpreted in detail. Then, weighted arithmetic water quality index (WAWQI) was used to evaluate the quality of the water samples and the potability level of the samples that were not properly addressed previously.

2. Material and Methods

2.1. Study area

Bursa is a city that owns 115 km. coastline along with the Marmara Sea, permeant lakes, and vast wetlands. It is known with surplus in water resources, snow packs at summit of Mount Uludag, and vast forests. The urban water is mostly provided from three main sources while the largest share belongs to the surface water resources. In this respect, the surface water resources in the region includes streams, natural lakes, as well as dams' reservoirs. More specifically, the Nilufer Stream, which has the largest catchment area in Bursa (680 km^2) is an important water resource (Figure 1) providing water for the city with help of the Doganci and Nilufer Dams [18]. The treatment processes of Doganci Dam at Doburca, was put into service in 1983 in order to meet the drinking water demand of the Bursa city, while the facility purifies an average of 270,000 m^3/day and meets 80% of the city's drinking water needs [19]. In the facility; the processes of enriching the water with oxygen and improving its taste and odour by aeration, removing the turbidity caused by suspended solids in the water with the help of chemical methods and making the water microbiologically clean by disinfection are carried out. The samples taken from Doğancı dam are located at 40°06'42.5 "N 28°57'45.8 "E. The location of the dam is shown in Figure 1.

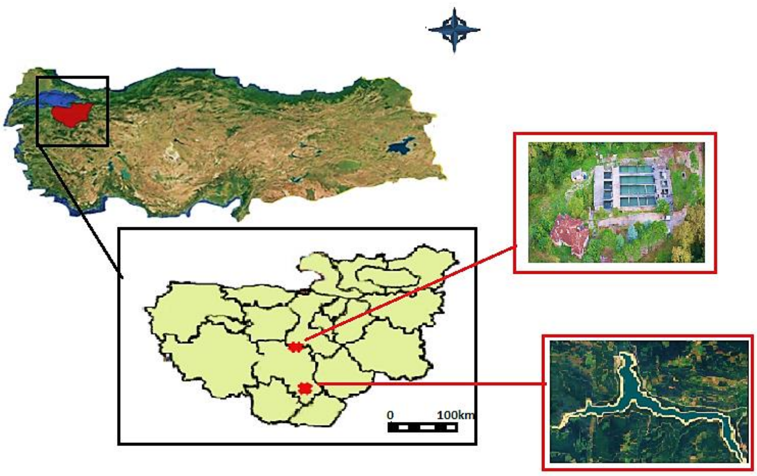

Figure 1. Doganci dam and water treatment plant location

2.2. Data used

The data used in this study were officially obtained from Doburca drinking water treatment plant. The data provided were recorded a total of 21 times between 04 January 2021 and 01 June 2021 to be taken every week, and the initial measurements and determination of the parameters were carried out by the facility. The analyses were carried out in Bursa Doburca drinking water treatment plant laboratory. In Table 1, the values obtained from the samples are given together with the standards provided by WHO and TSE 266. In the analyses, the new fourth generation UV-VIS spectrophotometer Hach Lange DR 6000 with RFID technology, designed and manufactured in Germany, was used. This device offers high-speed wavelength scanning across the UV and visible spectrum and comes with over 250 pre-programmed methods, including the most common testing methods used today.

Table 1. Suitability of the present study with different drinking water standards

PARAMETERS	METHOD	UNIT	TSE 266	WHO	Maximum values	Minimum values	Average values
Conductivity	SM 2510 B.	µS/cm	2500	2500	362.10	417	390.19
Nitrate	EPA300.1	mg/L	50	50	0.48	2.15	1.59
Iron	EPA 6020A	µg/L	0.20	0.30	0.5×10^{-2}	2.1×10^{-2}	1.01×10^{-2}
Arsenic	EPA 200.8	µg/L	0.01	0.01	0.1×10^{-3}	3.41×10^{-3}	1.9×10^{-3}
Copper	EPA 200.8	µg/L	2	2	0.1×10^{-3}	0.99×10^{-3}	0.56×10^{-3}
Nickel	EPA 200.8	µg/L	0.02	0.02	0.1×10^{-3}	2.69×10^{-3}	1.71×10^{-3}
Total Alkalinity	SM 2320 B.	mg/L	-	-	100	248	189.70
Dissolved Oxygen	SM 4500-OG	mg/L	-	-	9.10	10.69	10.18
Total Dissolved Substance	SM 2540 C.	mg/L	-	-	178	201	250.15
Total Hardness	SM 2340 C.	mg/L	-	500	170	196.60	187.80

2.3. Correlation analysis

One of the well-known methods for data and water quality evaluation is the correlation analysis. Correlation analysis examines the joint relationship between the dependent and the independent variables of any kind. In this study, the relationship between the water quality parameters was evaluated with the help of Pearson correlation coefficients (r). The correlation coefficient is very effective in expressing the level of the linear relation between two or multiple parameters. However, highs correlation does not imply causation or low correlation does not necessarily indicate to the absence of relationship between variables. Yet, the correlation coefficient if considered to be significant, is a sign for concordance between variables and can be approved or rejected by further analysis. In this respect, Table 2 provides the information regarding the examination of correlation coefficient and how it can be evaluated in the posterior analysis.

Table 2. Bench marks of correlation coefficient for posterior analysis [20]

Correlation coefficient range	Level
(-0.25) ~ 0.00 and 0.00~0.25	Very weak
(-0.49) ~ (-0.26) and 0.26~0.49	Weak
(-0.69) ~ (-0.50) and 0.50~0.69	Moderate
(-0.89) ~ (-0.70) and 0.70~0.89	Strong
(-1.00) ~ (-0.90) and 0.90~1.00	Very strong

After conducting the correlation analysis, regression models can be developed in evaluation of the parameters depicting strong correlation coefficients, and estimation of the concentration of other components. The systematic study of the correlation coefficients of the parameters helps making effective predictions in assessing the water quality. In addition, it not only supports measuring the relative concentration of pollutants in water and providing necessary clues for the implementation of water quality management programs, but the combined effect of strong correlations between different parameters makes serious contributions in the assessment of water quality [21].

2.4. Water quality index (WQI)

The WQI organizes large amounts of data and brings them together on a common denominator later to be separated into basic categories (excellent, good, poor, unsuitable). The WQI is an effective tool for comparing the water quality resources of different water bodies and provides a general idea of potential water-related hazards in a given area. The index is used as a very effective method in associating the trend of water quality data with water quality management [22,23]. Hence, the WAWQI can be calculated using the following equation [24].

$$\text{WAWQI} = \frac{\sum Q_n W_n}{\sum W_n} \quad (1)$$

while, Q_n is the sub-index for the water quality parameter; and W_n is the weight associated with the water quality parameter. The quality rating scale (Q_n) for each parameter is then calculated using,

$$Q_n = 100\left[\frac{V_n - V_i}{V_s - V_i}\right] \quad (2)$$

where, V_n in this equation is the estimated concentration of the *i*th parameter in the analysed water and, V_i is the ideal value of this parameter in pure water. $V_i = 0$ (excluding pH: 7.0 and DO: 14.6 mg/L). V_s is the recommended standard value of the *i*th parameter [13]. The unit weight (W_n) for each water quality parameter can be calculated as,

$$W_n = \frac{K}{V_s} \quad (3)$$

where, *K* is the proportionality constant and calculated as,

$$K = \left[\frac{1}{\Sigma\left(\frac{1}{V_s}\right)}\right] \quad (4)$$

Therefore, the degree of water quality according to the obtained value can be evaluated as given in Table 3.

Table 3. Water quality grading according to the WAWQI method [24]

WAWQI	Water Quality Status
0-25	Excellent
26-50	Good
76-100	Very Poor
Above 100	Unsuitable

3. Results and Discussion

3.1. Evaluation of water quality standards

Minimum, maximum and average values of 21 water samples are given in the study (Table 1). These values were measured weekly between January 2021 and June 2021. The concentration of each parameter was determined by Hach lange dr 6000 UV-VIS spectrophotometer and it was determined whether it was in the range of two different standards. In case of deviation of these parameters from the standard, each parameter was interpreted in detail in case of serious damage.

It is known that the Nitrate ion transforms into nitrite ion (NO_2^-), especially for babies younger than one-year-old, and causes *Methemoglobinemia* (blue-baby) disease. In this respect, when the nitrate ion (NO_3^-) concentration exceeds 50 mg/L, it becomes harmful for human being [25]. Considering this fact, the average value for the NO_3^- in 21 samples is 1.599 mg/L and therefore it is safe for consumption. *Fe*, also does not depict a negative effect on human health since its concentration is lower than 0.3 mg/L. However, one of the damages that may occur is the potential for bacterial growth in the water networks and a muddy sediment coating in the pipes [26]. *As* on the other hand, leaves serious toxic effects when its concentration is more than 0.01 mg/L in the water samples. In this respect, skin cancer, kidney diseases, skin diseases, vomiting and dizziness are some these symptoms. Given in the Table 1, the *As* value as 0.0019 mg/L is below the standard limit. *Cu* in the natural water resources, can be found as the aftermath of rock erosion or industrial activities. Although the copper is a nutritionally necessary element, its deficiency can cause diseases such as *Anaemia* and nervous system deterioration, yet the high concentration of *Cu* intake cause in digestive system disorders, liver, and kidney damage [26]. However, compared to the substances such as *Ni*, *As*, and *Zn* the toxicity rate is low, and its concentration rate is well below the boundary limit. The dissolved oxygen value of the water changes depending on the water temperature and the chemical, and the biological processes taking place in the water distribution network. Previous studies concluded that, if the dissolved oxygen rate is lower than 5 mg/L, it does not comply with the standards [14]. At low oxygen concentrations however, the aesthetic quality of the water (taste, odor, corrosion) is adversely affected due to the growth of undesirable anaerobic microorganisms. As can be seen from Table 1, the mean dissolved oxygen value in the current study is determined as 10.18 mg/L. Alkalinity has no known harm to the humans; however, moderately alkaline waters (less than 350 mg/L) combined with hardness tends to inhibit corrosion of metal pipes. If the alkalinity value exceeds 500 mg/L, it may be associated with high pH and hardness values. Especially above these values, in the case of reduced heat transfer in hot water systems, the costs increase significantly. The actual desired value range for alkalinity is 75-400 mg/L [27]. Finally, the TDS measures the total amount of dissolved minerals in the water. Solids are likely to be Iron, Chlorides, and Sulphate or any kind of mineral found on Earth. Dissolved minerals can produce an unsuitable taste or appearance and cause scale deposits to form on the pipe walls. Values of less than 500 mg/L for TDS are quite appropriate. In this context, the value of 250.15 mg/L measured in the study proves that the parameter complies with the standards. Therefore, it is concluded that the average rates of 21 samples given in Table 1 generally fulfils the requirements for eligible drinking water.

3.2. Correlation analysis

Determining whether there is a relationship between the parameters and also the strength of this relationship is an important step in water quality assessments. During the treatment of the water entering the plant, the quality of the effluent is determined by considering the relationship between the parameters instead of evaluating them separately. The correlation coefficient, which shows the strength and direction of this relationship, can be applied for two or more variables. In this study, the binary relationship of ten parameters was analysed and interpreted in the context of correlation analysis. The correlation matrix of the variables is given in Figure 2. This graph was obtained using the 2023 R1 software Rstudio programme. In the light of Table 2, some of the relationships can be considered as strong or very strong. In particular, it was determined that there is a very strong positive correlation between the EC and TDS. The stronger the correlation the bigger the value provided in the chart. A total of 210 water samples, 21 from each parameter, were taken in the study. Since it was found that the random data conformed to the normal distribution when tested, it was accepted that all data conformed to the normal distribution. According to Figure 2, the most of the parameters have near normal distribution while the correspondence between the selected parameters cannot be confirmed with the help of scatter diagrams by ease.

Alternatively, the positive linear correlation between EC and TDS is supported by the Figure 3a that depicts high concordance between horizontal and vertical axis on the perfect fit line. Conductivity is a measure of the capacity of the liquid to transmit an electric charge, but this parameter depends on the ion concentration and ionic strength, while the measurement of the dissolved ion concentration is usually done with TDS. In freshwaters, the major ions associated with the TDS are chloride, sodium, and magnesium [28]. Researchers have done various studies to express the relationship between these two parameters mathematically and have expressed the correlation of the parameters using,

$$TDS\ (mg/L) = k \times EC\ (\mu S/cm) \quad (5)$$

where the k value increases with the increase of ions in the water and changes depending on the type of water (sea water, irrigation water, fresh water, etc.). Hence, the relationship between EC and TDS can be evaluated depending on the activity of certain dissolved ions and the ionic strength. We also examined the relationship between the EC and NO_3^-. The correlation coefficient between these parameters depicts a strong bound of 0.80 indicating that there is a strong positive correlation between electrical conductivity and the nitrate concentration (Figure 3b). In the study of Rehman et al. [29], it was determined that the NO_3^- and EC correlation coefficients of two tehsils were quite low (r: 0.235; r: -0.123), and one was very high (r: 0.950) according to the data obtained from three different tehsils. Similarly, in the study of Mudgal et al. [30] monitored the hydro-chemical properties of groundwater in Alwar. Therefore, in this study, the suitability of groundwater for drinking and irrigation purposes and the relationship between parameters were investigated. NO_3^- and EC correlation coefficient was calculated as 0.8 and it was observed that there was a moderate positive correlation compared to other studies.

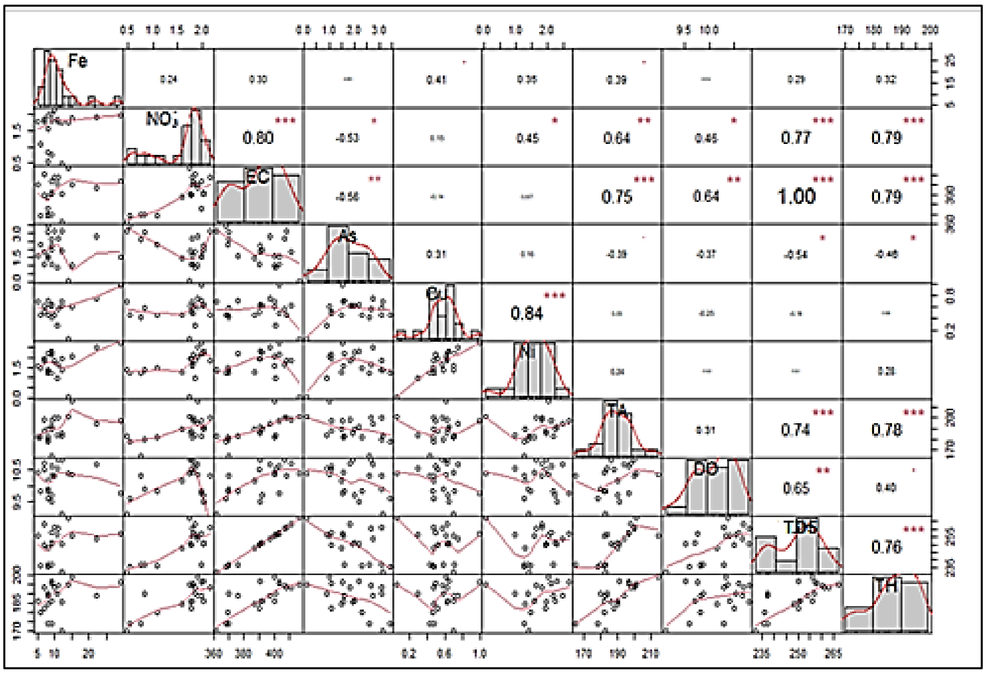

Figure 2. Correlation analysis of the parameters

The use of groundwater in studies may depict different from the coefficient in the current study. In addition, the geographical conditions of the regions and their impact on the available water resources can be examined to evaluate the difference. Afterwards, according to the obtained results there is a positive correlation of 0.842 between *Ni* and *Cu* (Figure 3c).

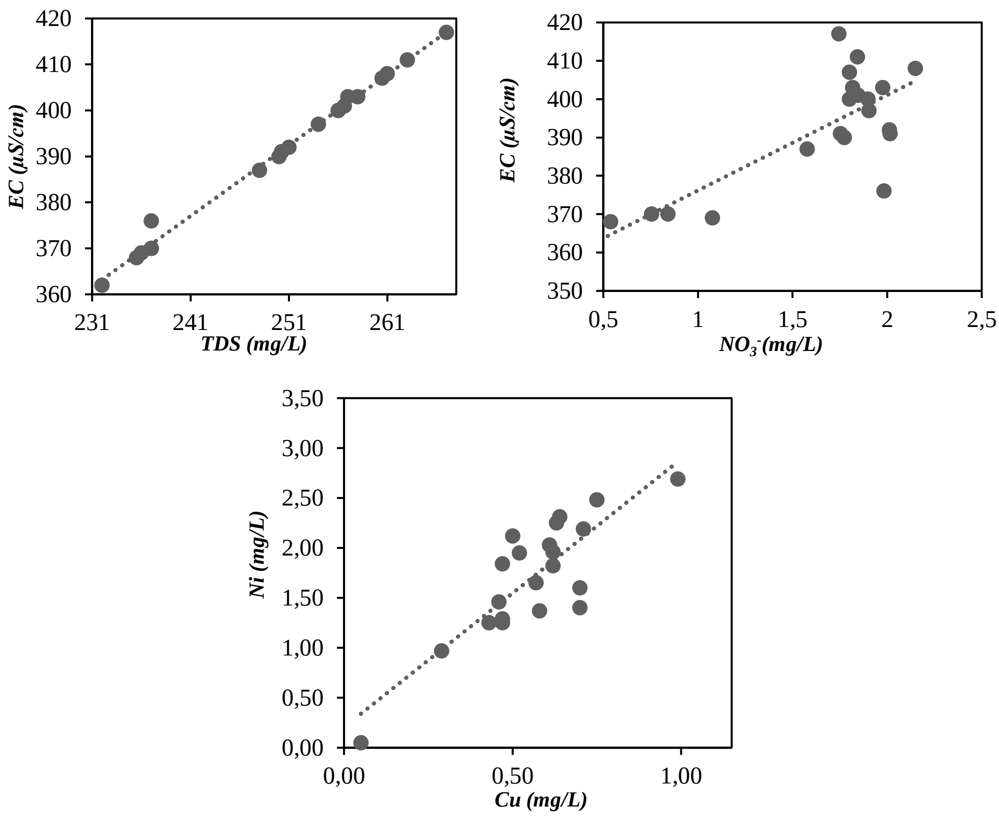

Figure 3. Correlation graph for a) EC and TDS b) EC and NO_3^- c) Ni and Cu

In many studies, it was aimed to determine the relationship between water quality parameters, and the relations including *Ni* and *Cu* were examined within the scope of the study. In the study of Tong et al. [16] as the value of the correlation coefficient between *Ni* and *Cu* was 0.6757, a positive moderate relationship could be associated with the allocated parameters. Since the water sources used in the study are of the surface water and household drinking water tabs, a close correlation coefficient relationship can be considered in our current study. On the other hand, in the study of Heydari et al. [17] it was determined that the correlation coefficient is about 0.254 and indicates that there is no relationship between these parameters. This is thought to be due to the difference between the selected time span of the present study and the study of Heydari et al. [17] who supplied samples from wells instead of surface water. For further comparison between all the allocated variables normalization is conducted that is given in Figure 4. Significant deviations were observed in *Fe*, *Cu* and *Ni* values on a monthly basis. According to Figure 4, the month in which these three parameters deviate together is April. In addition, the binary visual relation of the parameters whose correlation relations are given in Figure 2 can be deduced.

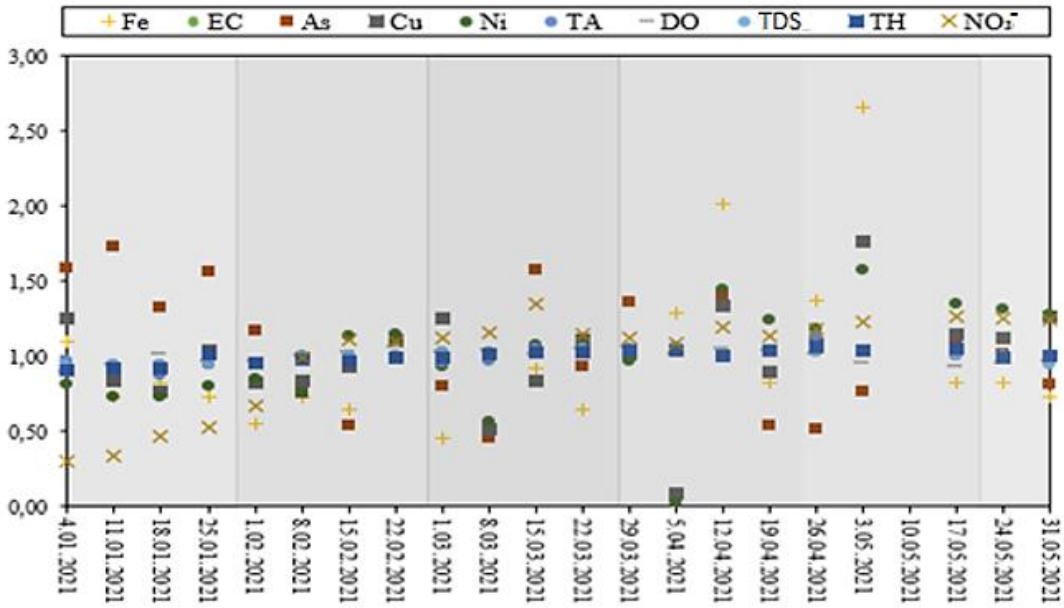

Figure 4. Weekly value comparison within the parameters

Since the value ranges and units of the parameters are different in Figure 4, standardisation was applied. In this way, a dimensionless comparison can be made. The deviation of the parameters together in certain months can be defined by correlation relations.

It is observed that the parameters that do not have a linear relationship, yet similar deviations occur at the same time. Therefore, the nonlinear relationship of these parameters, which do not have a linear relationship, was also examined and this situation was followed visually in Figure 5. A certain ratio of nonlinear relationships was found between the parameters that did not have a linear correlation ($r<0.5$). Hence the pairs with the highest R^2 value among the parameters that do not have a linear relationship is shown Figure 5.

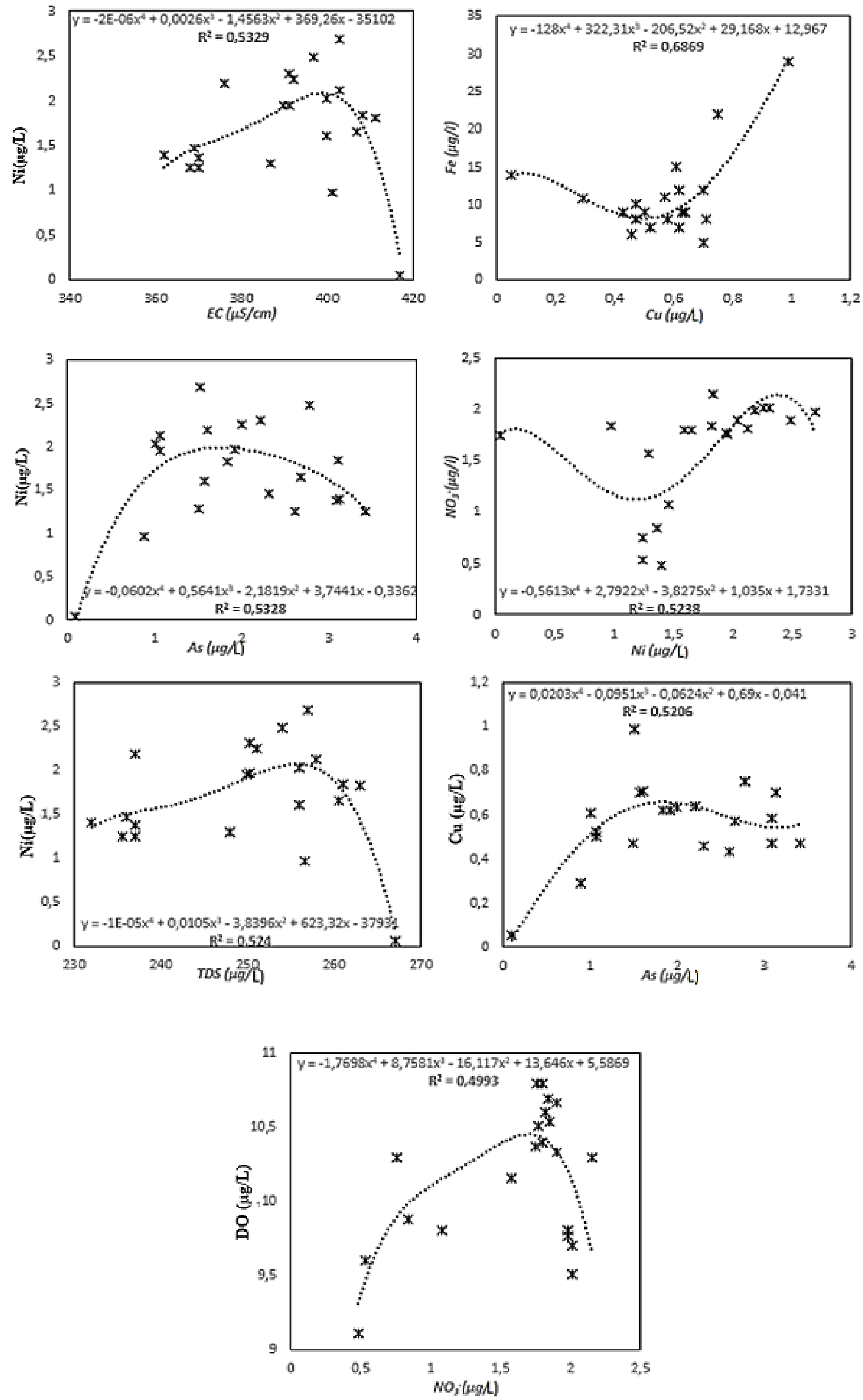

Figure 5. Nonlinear relations of parameters

3.3. Weighted arithmetic water quality index (WAWQI) analysis

World Health Organisation (WHO) standards are used in many drinking and potable water treatment plants. Testing the analyses with different standards is of great importance in terms of improving the quality of water [31].

In this context, unlike other studies, BIS standards were evaluated in WAWQI analyses in this study. While selecting the parameters to be used in the analysis, mostly heavy metals were preferred, as their high concentration cause serious harms. Therefore, in this study, the WQI method was preferred within the framework of BIS standards. In the study of García-Ávila et al. [32] compared the Council Water Quality Index (CCME WQI) with the Arithmetic Water Quality Index (WAWQI). As a result of the study, the standard values used in calculating the WAWQI value showed that more precise and accurate results were obtained. As a result of the limited number of parameters used, these two indices could be compared. Compared to WAWQI, the algorithm used to calculate the CCME WQI does not include any subscripts. However, the index is quite generic and requires careful selection of parameters and it was found that it does not take into account the weights between parameters. In this context, the index used in the study keeps the drinking water quality standard range in a more reliable range. According to Table 4, the mean values (V_n) of nine parameters were taken and expressed mathematically within the framework of the standards. As a result, the WAWQI value was calculated as 15.50 and in the light of Table 3, the suitability of drinking water was determined to be at the "excellent" level. In the study of Aydin et al. [33] determined the water quality of seven major streams in Giresun province. Complex data were evaluated by WQI and several important multivariate techniques. According to the WQI results, all streams were characterised with a "good water" quality rating and are suitable for drinking water. Similarly, PCA/FA, HCA, correlation matrix, one-way analysis of variance (ANOVA), pollution sources, spatio-temporal variations in water quality parameters and differences between stations were revealed. WQI values calculated using annual average water quality data did not show much difference between the streams. The minimum WQI value was measured in Gelevera Stream with 25.69 and the maximum WQI value was measured in Batlama Stream with 32.39 and all streams were classified as good quality ($25<WQI<50$). In another study Sener et al. [34] conducted in the Aksu River in the Mediterranean region, WQI results showed that the water quality of the Aksu River is not suitable for drinking, mainly due to industrial, municipal wastes and agricultural activities along the river. The results of the analysis were compared with the maximum permissible limit values recommended by the World Health Organisation and Turkish drinking water standards. Water quality for drinking purposes was assessed using the water quality index (WQI) method. The WQI values calculated in the study are between 35.6133 and 337.5198. The wide range of WQI of the area indicates that it is not reliable for drinking water. In addition, 300-odd values indicate the presence of heavy metal concentration in the water.

Table 4. Coefficients of the WAWQI

Parameters	BIS Standards (Sn)	W_n (Unit Weight)	Mean Observed Value (V_n)	Q_n (Quality Rating)	Q_n*W_n
EC	250	$2.60*10^{-5}$	39.19	15.67	$4.08*10^{-4}$
NO_3^-	45	$14.47*10^{-5}$	1.59	3.53	$5.11*10^{-4}$
As	0.01	0.65	$1,9*10^{-3}$	19	12.37
Fe	0.30	0.02	0.01	3.76	0.07
TDS	1000	$6.51*10^{-6}$	250.15	25.01	$1.63*10^{-4}$
TA	200	$3.26*10^{-5}$	189.72	94.86	$3.09*10^{-3}$
TH	300	$2.17*10^{-5}$	187.81	62.60	$1.36*10^{-3}$
DO	5	$1.30*10^{-3}$	10.18	203.60	0.26
Ni	0.02	0.32	0.002	10	2.78
		1			**15.50**
$WQI= \sum W_nQ_n / \sum W_n = 15.50$					

4. Conclusions

This study evaluates the treatment of Doganci dam's resorvoir water and the production of drinking water for Bursa, by addressing 10 water quality parameters and assosicated standards using different analysis methods. The results of the data obtained by measuring 21 samples taken between January 2021 and June 2021 acquired at weekly frequency are as follows:

- A very strong positive correlation was obtained between EC-TDS (r:0.99), Cu-Ni (r:0.842) and (NO_3^-)-EC (r:0.80).
- The parameters that do not have a linear relationship were also examined and a high nonlinear relationship was found especially between Fe-Cu.
- The result of WAWQI, which is one of the WQI methods, was obtained as 15.50 and it was interpreted that the drinking water quality for Bursa was at a potable level, and classified as “excellent”.

In addition to the present study, examining the relationships between different indices in future studies will be of great benefit in determining the WQI method on a subject-based basis. Analysing the values obtained by researchers using the WAWQI method using different water quality parameters will contribute to obtaining the details of the method. Continuous inspection of drinking water is an undeniable activity for sustainable water resources management and resilience against climate change. Hence, studies that constantly monitor and develop these activities, accelerate the inspection process of continuous development.

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