Caspian Journal of Environmental Sciences
Online ISSN: 1735-3866
Print ISSN: 1735-3033

Statistical and graphical analyses of water quality and quantity for the rivers in North Iran (Case study: Polroud and Sefidroud rivers)

M. Akbarpour Bazargani[1], Ebrahim Amiri[1*], Majid Ashouri[2]

1. Department of Water Engineering, Lahijan Branch, Islamic Azad University, Lahijan, Iran
2. Department of Agronomy and Plant Breeding, Lahijan Branch, Islamic Azad University, Lahijan, Iran

** Corresponding author's E-mail: eamiri57@yahoo.com*

ABSTRACT

Assessing surface water quality characteristics is essential in water resource management planning, such as assessing basin health and managing changes. Therefore, in this study, a comparative measurement of water quality changes in the Polroud and Sefidroud rivers in Gilan province, Iran, has been made using statistical and graphical methods. This study used the recorded data of water quality variables in two hydrometric stations of the Polroud and Sefidroud rivers from 1999 to 2018. Schuler diagrams were used to evaluate drinking quality, Wilcox for agricultural quality, Piper to use water type, Mann-Kendal method to examine time series, and Pearson correlation test to examine the relationships between parameters. According to the results obtained from the Schuler diagram, the water quality of the Polroud River is in good condition in terms of drinking water over 20 years, and the Sefidroud River is in good condition. The Wilcox diagram of Polroud River showed that the condition of agricultural water consumption of Polroud River is in C2S1 condition, which shows that the water quality condition is suitable for agriculture. Still, the results of this diagram for Sefidroud River showed that in spring, water in The C3S1 area is located, which indicates the average water quality of the river, while in summer, autumn, and winter, the water is located in the C2S1, and C3S1 area, which indicates the fluctuation of water in this area in the good and average range. Based on the Piper diagram, the water of both rivers is corrosive and hard. The results of qualitative statistical analysis of the parameters studied in this study for the two rivers showed that in the period from 1999 to 2018 in the summer, the measured parameters have high values compared to other seasons so that the highest arithmetic mean for the index EC in this season is equal to 290.85 mg L^{-1} for Polroud river and 314.66 mg L^{-1} for Sefidroud river, Total Dissolved Solids (TDS) index for Polroud river is equal to 246.3 mg/lit and for Sefidroud river is 277.5 mg L^{-1} and PH index for Polroud river is equal to 7.65 and for Sefidroud River was 7.79. Also, the study of the significance level of the Pearson correlation test for the studied parameters in Polroud showed that the Ca, Mg, Na, and K indices with a significance level of 0.038, 0.042, 0.015 and 0.024, respectively, were directly correlated with the EC index. This is consistent with the results obtained for Sefidroud River that the significance level of Ca, Mg, and Na indices with EC index were 0.024, 0.034, and 0.022, respectively, indicating the direct relationship between them. In general, the results showed that there is not much difference in the qualitative and quantitative changes of the two rivers in the period under study, and the role of human influence as a common factor in increasing pollution in these two rivers is evident.

Keywords: Total dissolved solids, River, Wilcox diagram, Iran.
Article type: Research Article.

INTRODUCTION

In integrated water management, maintaining water quality, especially in areas facing relative limitations of water resources, is one of the pillars of planning. Rivers are subject to many changes apart from their natural changes. Various elements and compounds in water affect the chemical and physical quality. In the meantime, the study of anions and cations can show many properties of water, and with their help, other water properties can be determined. Effective physicochemical parameters in water include fluorine, chlorine, sodium, sulfate, iron, total hardness, soluble solids, and electrical conductivity. High concentrations of chlorine cause flavor in drinking water. For example, the taste threshold for chlorine anion depends on the type of cation combined with it. The threshold for chlorine, sodium, calcium, and potassium is 200-300 mg L^{-1} (Dindarloo *et al.* 2006). Surface water resources are significant in meeting the country's water needs. The average rainfall in Iran is about one-third of the average land area and does not have a uniform time distribution in most parts of Iran. Assessing water resources is a very important and necessary issue to improve the problem of point and non-point pollution. Pollution of surface water due to human activities in agricultural lands and gardens through pesticides, pesticides, and improper use of chemical fertilizers and urban areas through sewage systems, contaminant tanks, ducts, waste, and effluents, increasing industries with chemical waste. Hydrologists and environmental protection experts have considered it a critical issue in water quality. If surface water resources are contaminated, removing or reducing pollution is costly and requires a long time, so continuous monitoring or monitoring of water resources is essential. Water quality is declining due to important factors such as population growth, industrialization, and urbanization, and the amount of water quality in each region can be assessed based on physical, chemical, and biological parameters. Contaminant sources include substances that, if introduced into the climate, soil, and plants, make it unnatural and useful and alter water's physical, chemical, and biological properties. These substances are mainly caused by human activities and are divided into three main groups: industrial, urban, and agricultural sources of pollution (Mirzaei *et al.* 2017). Surface water is more exposed to pollution, and continuous measurement and analysis of river quality parameters to determine water quality is considered a principle. River pollution is one of the most critical problems in the world today, especially in developing countries. Assessing surface water quality characteristics is also essential in water resource management planning, such as assessing basin health and managing changes. Water quality protection is considered one of the pillars of integrated water management planning. Water quality is very important for the health of the river and the preservation of environmental processes. Improving water resources is essential for environmental protection and economic, political, social, and cultural development in a country. The effects of anthropology and natural processes cause surface water pollution (Li *et al.* 2019). One of the appropriate ways to prevent water pollution is to evaluate surface water pollution using graphical methods and determine the degree of water pollution to prevent pollution development. The hydrogeochemical properties of water play an essential role in determining its use for drinking, irrigation, and industrial purposes. Statistical methods are also used to assess water quality and surface water pollution levels in the water resources pollution assessment discussion. In multivariate statistical methods, it is possible to eliminate ineffective factors and parameters and use the correlation relationships between spatial variables and the amount of pollutants in surface water. It is a quantitative method in water quality management (Kamasi & Sharghi 2016). Various studies have been conducted to investigate the qualitative changes in rivers. Motamedi Rad *et al.* (2021) evaluated the quality of water resources in drinking, agriculture, and industry in the karst aquifer of Rouin Esfarayen in North Khorasan Province. Regarding industrial use, the water quality of springs in the region also showed that all water samples, except Sangwa spring, which has water with sedimentation properties, have corrosive properties. In another study, Jafari *et al.* (2021) evaluated the quality of water resources for drinking and agricultural use (Case study: Gamasiab catchment, Kermanshah Province). The results showed that according to the Wilcox diagram, all samples are in the S2C1 class range, which indicates good quality water for irrigation and agriculture. Buss & Achten (2022) also studied surface water quality in a medium-sized river basin (Northwestern Germany) for agricultural and urban use over five years with arid summers. The analysis showed that manure from agricultural lands is the primary source of nitrate, while the impact of municipal wastewater treatment plants was ignored. In another study, Akoto *et al.* (2020) conducted a comprehensive assessment of surface water quality and the potential health risks of the Sisa River in Kumasi. The principal component analysis showed three factors that make up about 98.86% of the total variance in the surface water quality data set. Pant *et al.* (2021) in their research on the "quarantine effects of the corona epidemic on the surface water quality of the Bagmati River Basin in Nepal". Multivariate statistical analysis of this study confirms that significant recovery of degraded aquatic ecosystems is possible by limiting human activities. In another study, Yang *et al.* (2021) investigated the effects of surface pollution on urban river water quality under rainfall events in the Woking District of Tianjin Province, China. The main was to reduce the concentration of pollutants. The results show that runoff should be considered when considering surface pollution's effects on urban rivers' water quality. In a study, Han *et al.* (2019) responded to the quantity and quality of surface water in the extreme agricultural water consumption in the Hutuo River Basin upstream in China. This study showed that the spatial distribution of flow, salt and stable isotopes reflects changes in regional water efficiency and consumption intensity. Therefore, this study aims to measure and compare the quantitative and qualitative changes in the water of the Polroud and Sefidroud rivers in Gilan province, Iran, using statistical and graphical methods.

MATERIALS AND METHOD

Physiographic characteristics of Polroud and Sefidroud catchment. Polroud catchment area is located in the north of Iran, east of Guilan Province and Rudsar City, so from the north to the Caspian Sea, from the south to the Shahroud catchment and Alborz Mountains, from the west to the Shalman River catchment and from the east to the dry river basin. Polroud River is the most watery river of Gilan after Sefidroud and consists of two main tributaries. The first branch originates from the Eshkor Heights and forms the Polroud branch with the Tinkarud and Kakrud rivers. The second branch, which springs from the mountains of Deilaman and ShahiJan and Lesbo, is known as Chakroud. These two branches join at May Pol and have since formed Polroud. The Polroud catchment area in Tulalat station, which is the water meter station of this river, is 1564 square kilometers, and the average height of the catchment area is 1883 meters. The length of the river's main tributary is 60 km, and the area of water intake lands of this river is 8147 hectares. The annual rainfall in this basin is 1356.4 mm. Sefidroud catchment, with an area of about 67,000 km^2 is located between 30° 46´ to 15° 51´ east longitude and 45° 35´ to 45° 37´ latitude. Sefidroud River originates from the confluence of the two main tributaries of Ghezel Ozan and Shahroud from the provinces of Kurdistan, Azerbaijan, and Markazi. It leads to the Caspian Sea in Guilan Province in the port of Kiashahr at an altitude of -20. Studies show that the average annual rainfall in this catchment area varies between 25 to 1650 mm. Also, the average annual temperature in this area is between less than 5 degrees Celsius and more than 18 degrees Celsius.

Data used. This study used the recorded data of water quality variables in the hydrometric station of the measured rivers from 1999 to 2018. These variables include magnesium (Mg), calcium (Ca), potassium (K), chloride (Cl), Bicarbonate (HCO3), sulfate (SO4), and sodium adsorption ratio (SAR). These data were obtained from the Regional Water Organization of Guilan Province. The water quality of the studied rivers was studied for capability in drinking water using the Schuler diagram and from the point of view of consumption in irrigation and agriculture with the method of Wilcox diagram and in terms of industrial use from Piper diagram (Arain *et al.* 2015). Chemistry software was used to perform these analyses. Three graphs of Wilcox, Piper, and Schuler were used for analysis in the software. The Wilcox diagram assigns the horizontal axis to water salinity and electrical conductivity in micromoles per centimeter and the vertical axis to sodium absorption ratio. The coordinates of each water are located in an area denoted by the letters S in terms of salinity and C in terms of alkalinity. Also, the values 1, 2, 3, and 4 indicate low, medium, high, and very high, respectively. In terms of water characteristics of different classes, Bai stated that the waters of group C1S1 have a very good quality, the waters of group C1S2, C2S1, C2S2 can be used for agricultural purposes, group C1S3, C2S3, C3S1, C3S2, C3S3 can be used for soils with light texture. Moreover, water can quickly be drained from them. Two waters of C1S4, C2S4, C3S4, C4S3, C4S4, C4S2, C4S1 are unsuitable for agricultural purposes and can be used only in certain conditions for plants in particular (Han *et al.* 2019). The Piper diagram is made up of a combination of three separate squares. The percentage of anions and cations in triangular fields and their combined positions are implemented in a rhombic field. In this way, the percentage is found on the side corresponding to the anions and a line is drawn parallel to the side which is 100% corresponding to the vertex opposite the anion. In this way, three lines intersect at a point are drawn. Then, the same thing is done for the cations in the left triangle to get another point. These two points are then extended parallel to the sides of the rhombus to intersect at the point between the rhombuses. The Piper diagram shows water's chemical properties relative to its components' concentrations. The type of water can be quickly identified in the Piper diagram (Ramachandran *et al.* 2019). Schuler diagrams are also semi-logarithmic diagrams used to show the primary ions in milligrams per liter and the chemical differences of the samples in a diagram (Ramachandran *et al.* 2019). Numerous statistical methods have been proposed to analyze the trend of time series, which can be divided into two general categories: parametric and non-parametric. Some data sets generally do not follow a normal distribution. A rank test such as the Monkendall test can be used in this case. This test does not require the frequency distribution of normal or linear data behavior. The steps of this test are as follows:

A) The data are arranged in order, and the chronological order of the data is considered n.
B) For this purpose, the data are ranked using the T-statistic (ratio of rank 1 to previous rankings).
C) Mathematical expectation, variance, and Mann-Kendal index are calculated.
In this test, two-time indices, U (ti) and U′ (ti), which are statistical data for the time period, respectively, have been used (Zahedi *et al.* 2006).
The Pearson torque correlation coefficient was used to examine the two-variable correlation. The Pearson coefficient shows the extent to which there is a linear relationship between quantitative variables. The main use of the Pearson coefficient is when the variables are parametric; That is, they have a normal distribution and are at a distance / relative level. As a result, this test describes the intensity of the relationship between variables. Before using this test, the normality of the data was checked, and the data were tested for normality. In this study, the Kolmograph-Smirnov test was used to check the normality of the data, and the results indicated that the data were normal. For this reason, because the scale of the studied parameters was normal, Pearson parametric correlation tests were used (Treiblmaier & Filzmoser 2010).

RESULTS AND DISCUSSION

Polroud River

An overview of the Wilcox diagram for the seasons is shown in Fig. 1. According to this study, the chemical quality of watershed water resources for agricultural use has not changed much and is not in different classes. According to the results obtained over twenty years and due to the full water of Polroud and discharge, this river is acceptable in all water seasons in the C2S1 range, which is a suitable water type in terms of use in agriculture. Therefore, water from the Polroud River in the study area is not limited to agriculture and is quite suitable. The results of the Piper diagram for the Polroud River to classify water quality in industrial use are shown in Fig. 2. The results show that the water is usually relatively hard in the first spring. However, in the rest of the seasons, the water is hard, and with all the available parameters, the water is completely corrosive. The concentration of the samples in the Piper diagram indicates that the water of the Polroud River is located in area 70, which is related to the calcium-magnesium type. Also, the location of the samples in the w1 region indicates the calcium type and the bicarbonate-carbonate type is indicated in the w7 region. Fig. 3 shows the classification of drinking water in the maximum and minimum conditions on the Schuler diagram. The results showed that in all parameters and in all the studied seasons, the drinking water situation is in the range of good to acceptable, and there is no barrier to drinking water for this river.

Sefidroud River

Fig. 4 shows the results obtained for the qualitative classification of water consumption and irrigation in agriculture of Sefidroud River using Wilcox diagram. The results showed that the agricultural water status for Sefidroud River in 20 years in spring and summer is in the range of C3S1, which indicates the average water status used. However, in the two seasons of autumn and winter, it is in the range of C2S1 and C3S1, which indicates the suitable water condition of this river for agricultural consumption. In general, the water quality of Sefidroud River is acceptable for irrigation and agriculture. The Piper diagram results for Sefidroud River to classify water quality in industrial use are shown in Fig. 5. The results showed that the water situation is in the range of 40 to 50, which indicates the hardness of water in the four seasons. Calcium and magnesium cations. predominate in the water used during these 20 years, and in addition, water contains carbonate and bicarbonate compounds. Fig. 6 shows the classification of drinking water in the maximum and minimum conditions on the Schuler diagram. The results showed that in all parameters and seasons under study, the water situation in terms of drinking is in the range of good to acceptable, and there is no barrier in drinking water for this river. Table 1 compares the results obtained from graphic analysis for the Polroud and Sefidroud rivers in Guilan Province. Based on the results obtained from the Schuler diagram, the water quality of the Polroud River is in suitable condition in terms of drinking in twenty years and for spring, summer, autumn, and winter. The results of the Wilcox diagram, which examines the quality of river water in terms of agriculture, showed that the state of agricultural water consumption in the Polroud River is in the C2S1 state, which indicates that the state of water quality in terms of agriculture is good and appropriate. The study of the industrial condition of the water of the Polroud River showed that in all seasons, the condition of the water in the corrosive state has been relatively hard.

Also, the water status of the Sefidroud River in the east of Gilan province showed that this river is in good condition regarding drinking water. In contrast, the water quality for agricultural use, according to the results of the Wilcox diagram, showed that in spring, the water is in the C3S1 range. This indicates the average water quality of the river, while in summer, autumn, and winter, the water is in the range of C2S1 and C3S1, which indicates the fluctuation of water in this area in the range of good and average. The water of this river is also corrosive and hard.

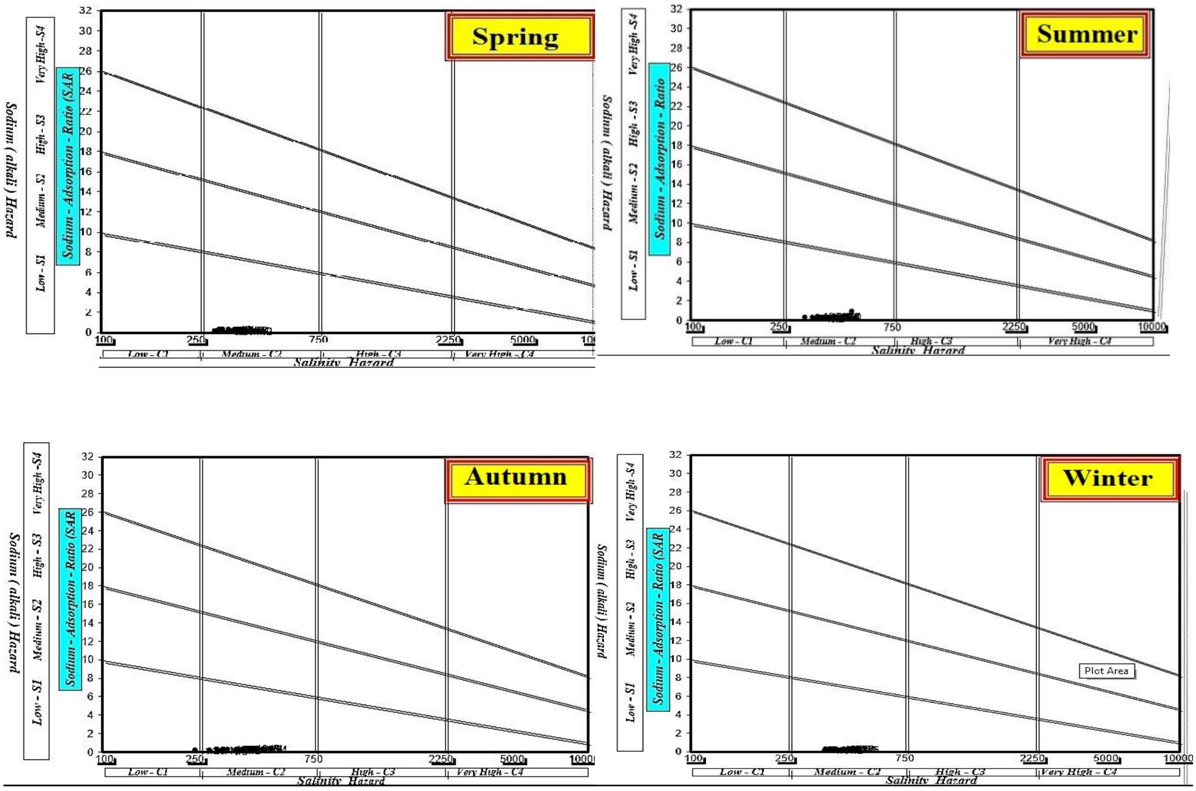
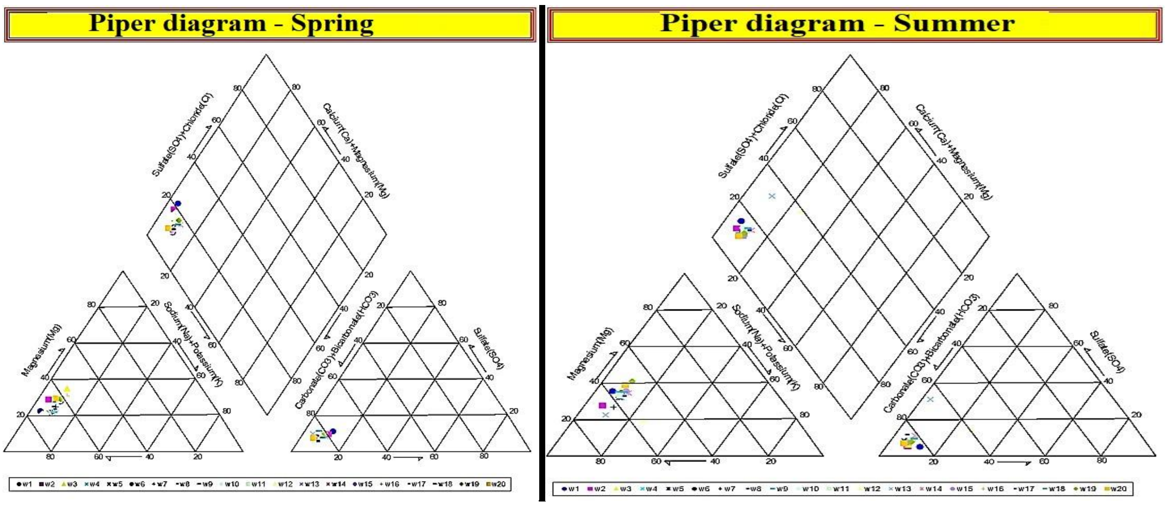


Fig. 1. Results of the Wilcox diagram for the Polroud River.



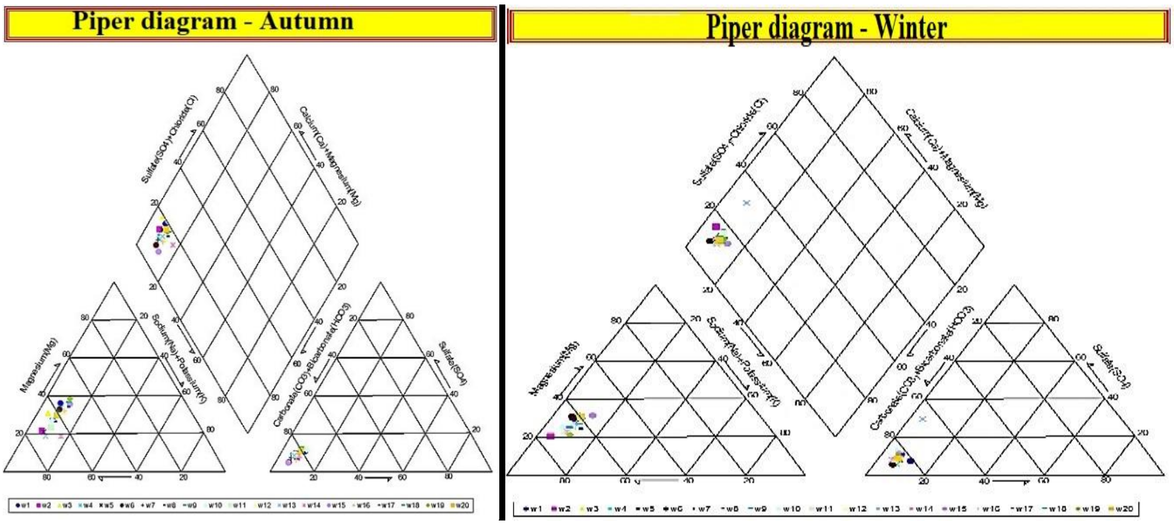


Fig. 2. Piper diagram results for the Polroud River.

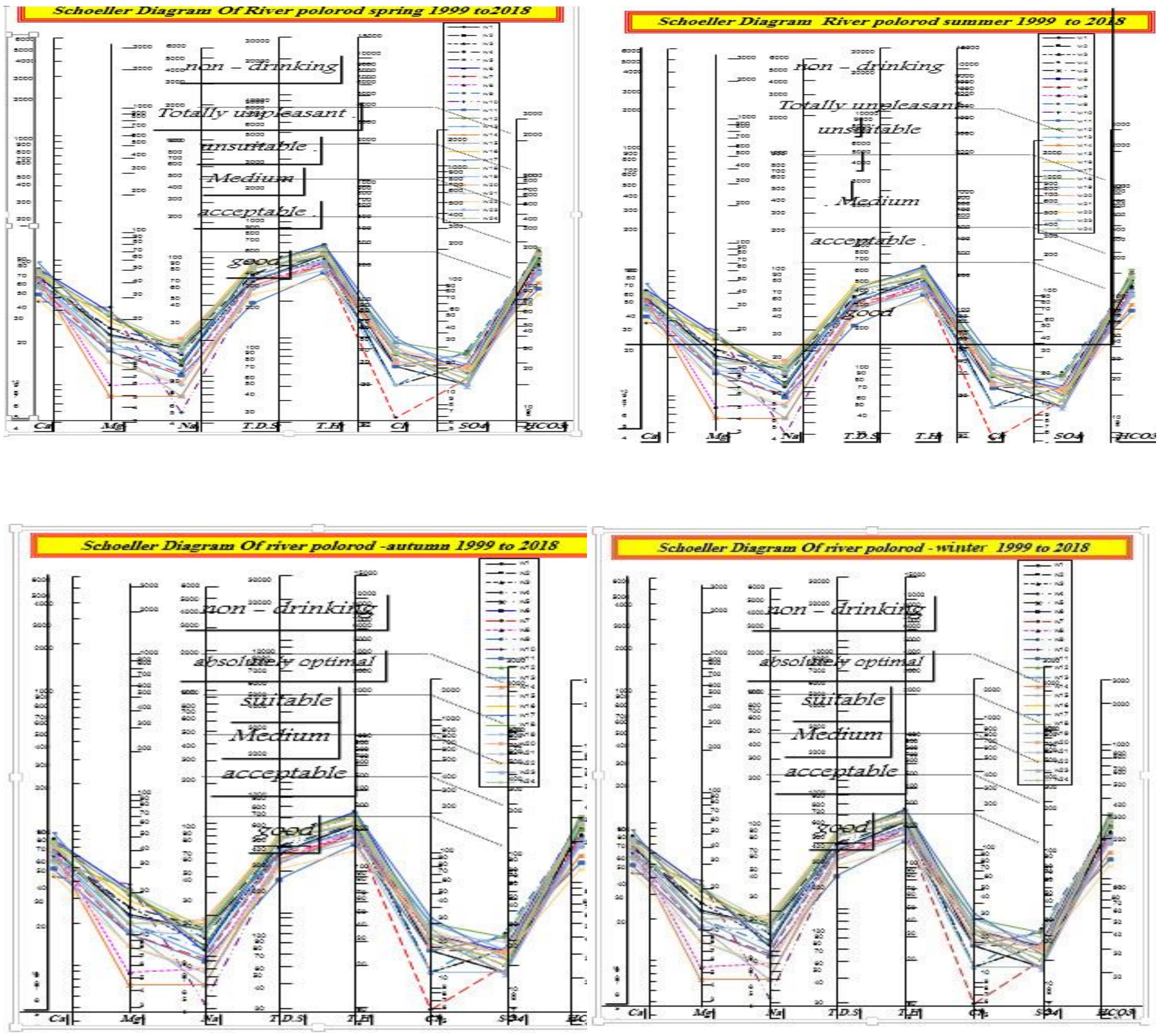


Fig. 3. Results of the Schuler diagram for the Polroud River.

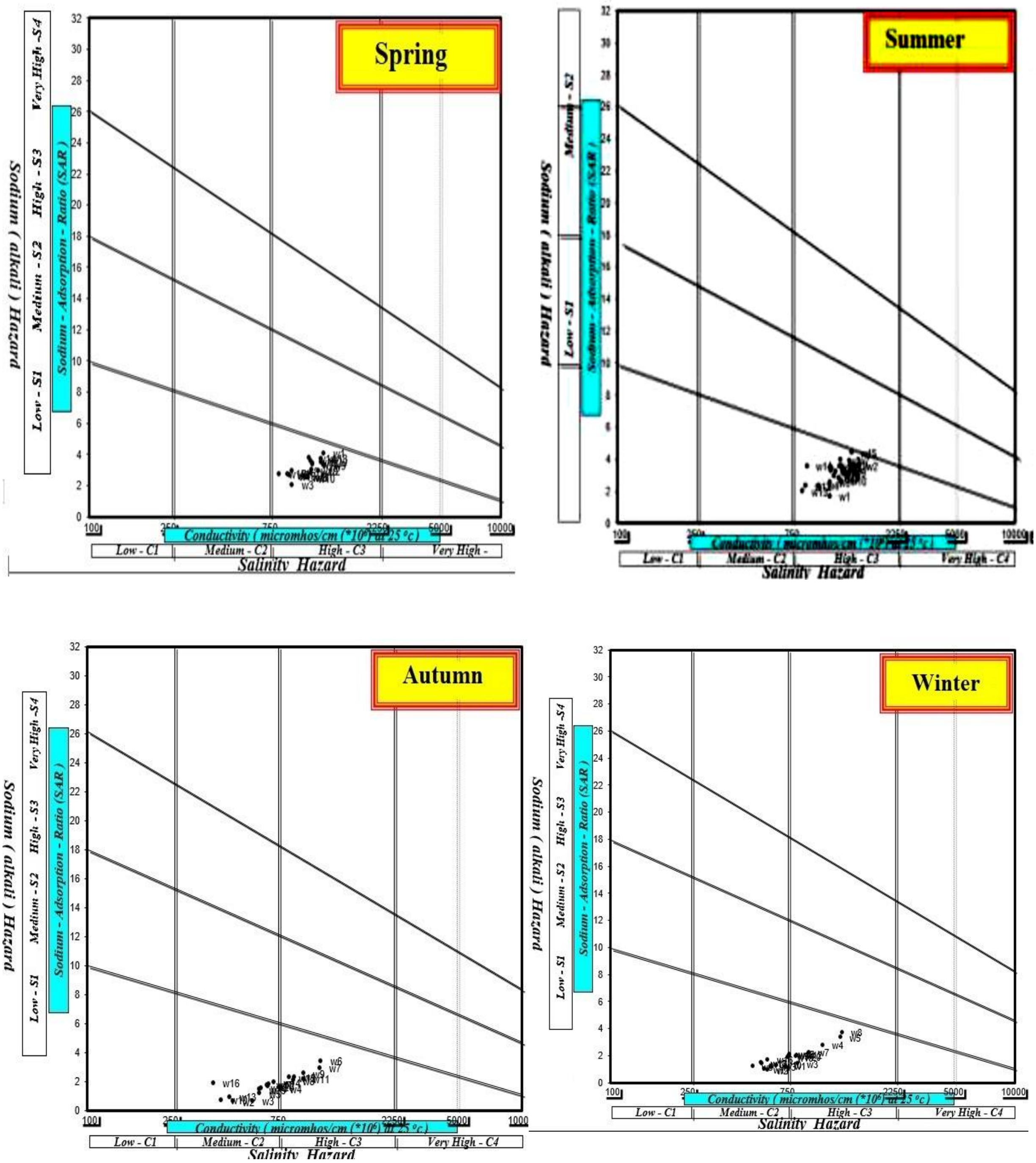


Fig. 4. Results of Wilcox diagram for Sefidroud river.

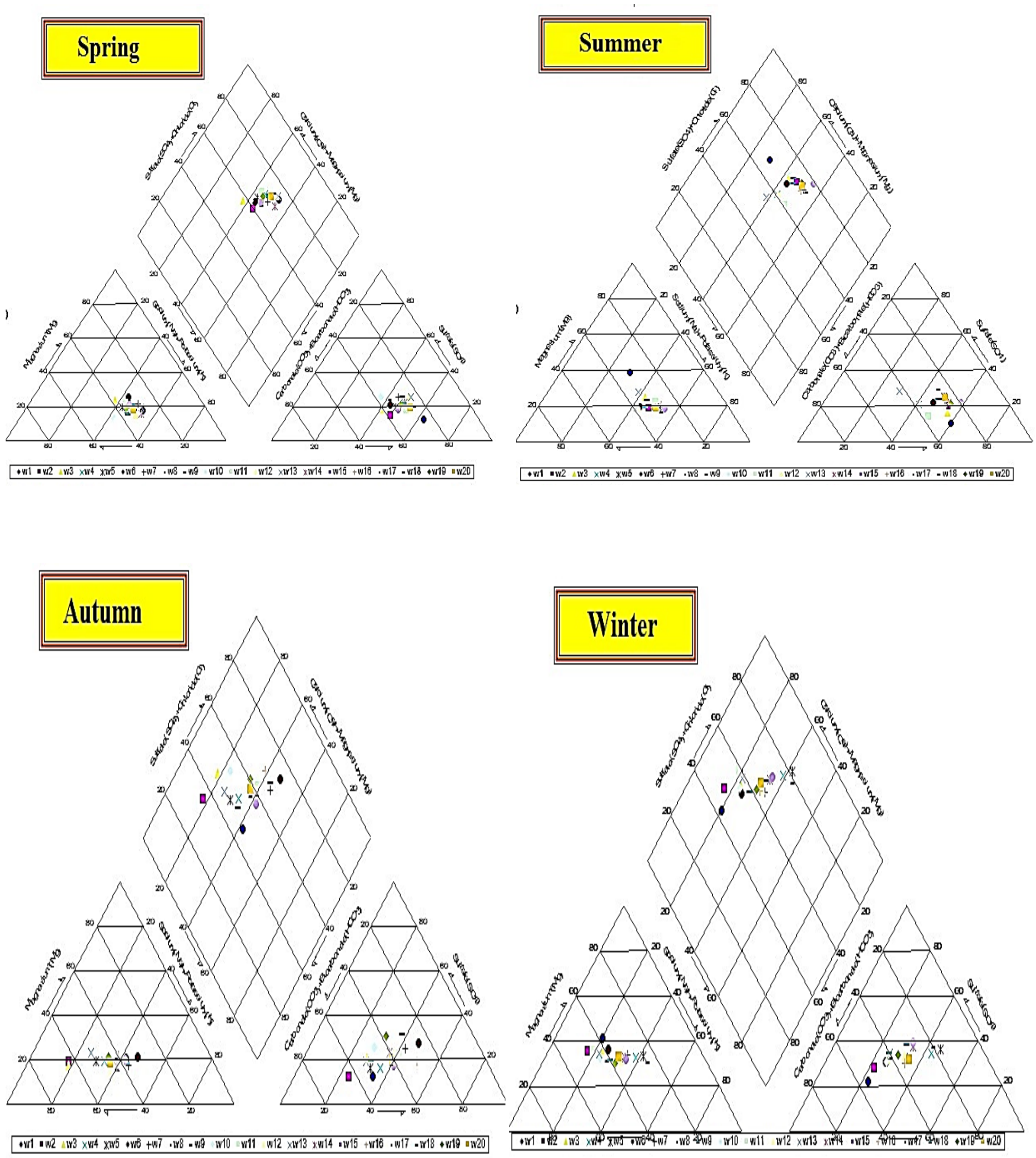


Fig. 5. Piper diagram results for Sefidroud river.

Table 1. Comparison of graphic analysis results for Polroud and Sefidroud rivers in Guilan province.

Rivers under study	**Drinking (Schuler)**				**Agriculture (Wilcox)**				**Industrial (hardness)**			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
Polroud	Good	Good	Good	Good	C2S1	C2S1	C2S1	C2S1	Relatively hard corrosive	Hard corrosive	Hard corrosive	Hard corrosive
Sefidroud	Good	Good	Good	Good	C3S1	C2S1 C3S1	C2S1 C3S1	C2S1 C3S1	Hard corrosive	Hard corrosive	Hard corrosive	Hard corrosive

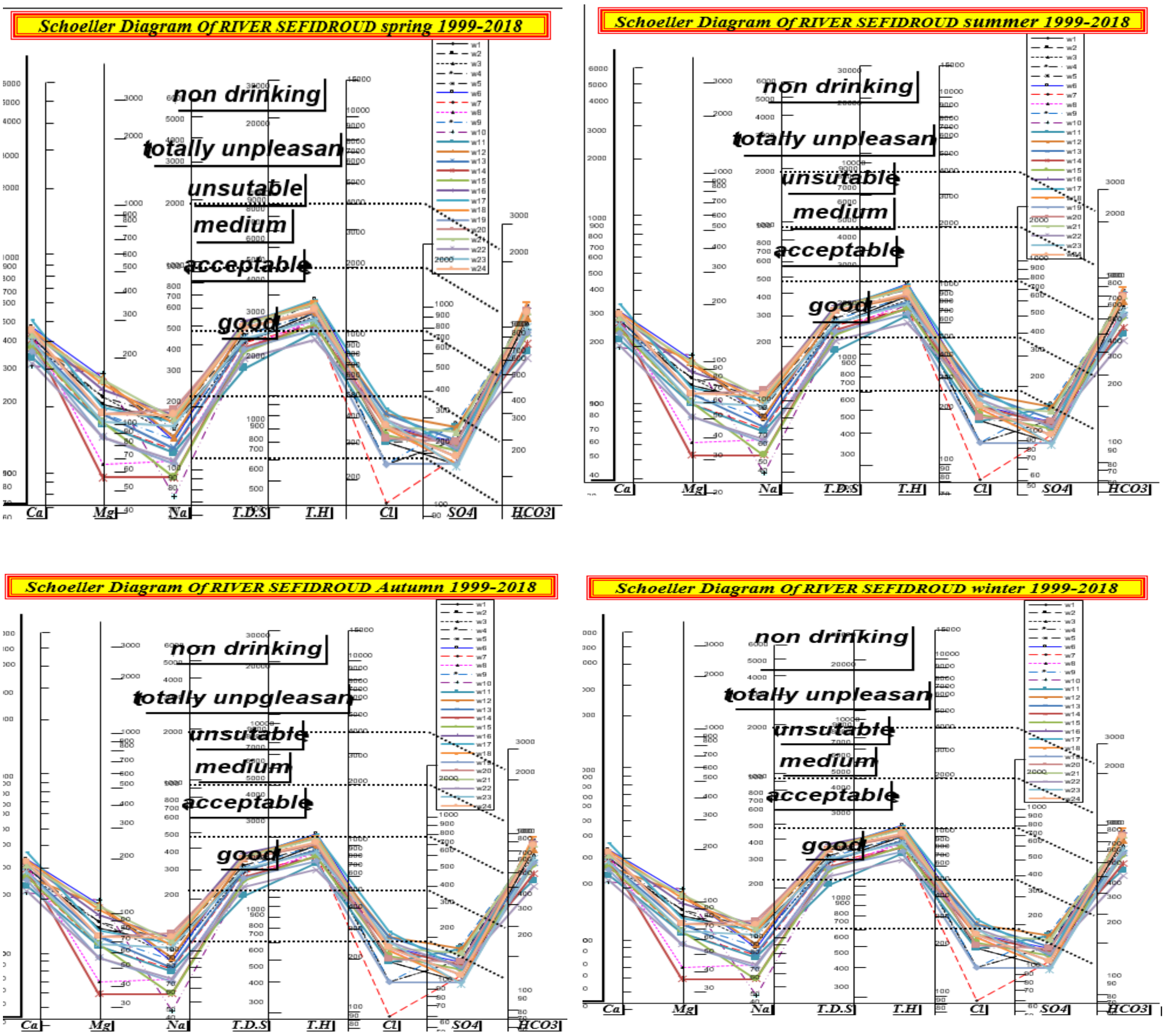
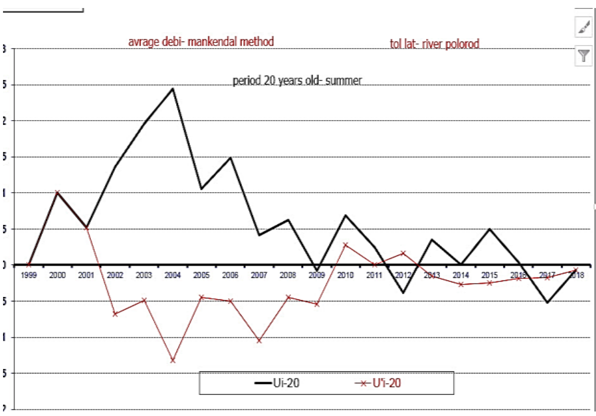
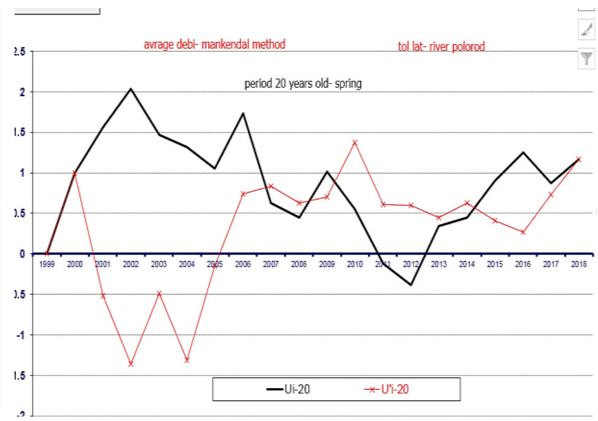


Fig. 6. Results of Schuler diagram for Sefidroud river.





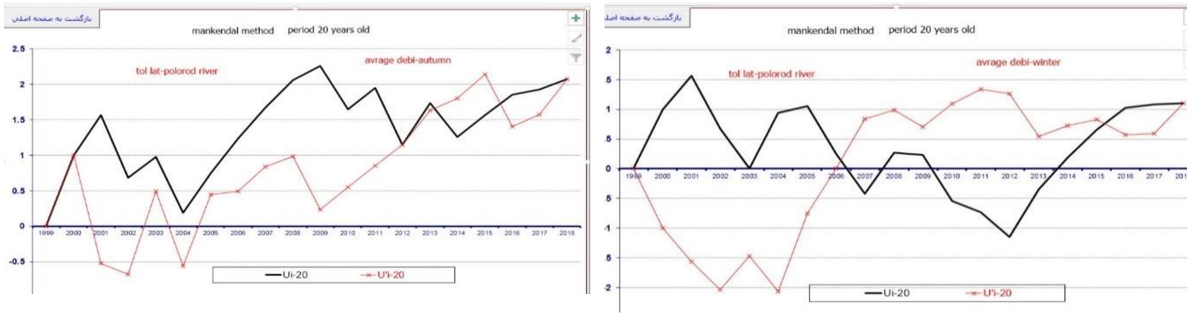


Fig. 7. Results of determining the 20-year average discharge points of the discharge for the Polroud River in the studied seasons by the Mann-Kendal ranking method.

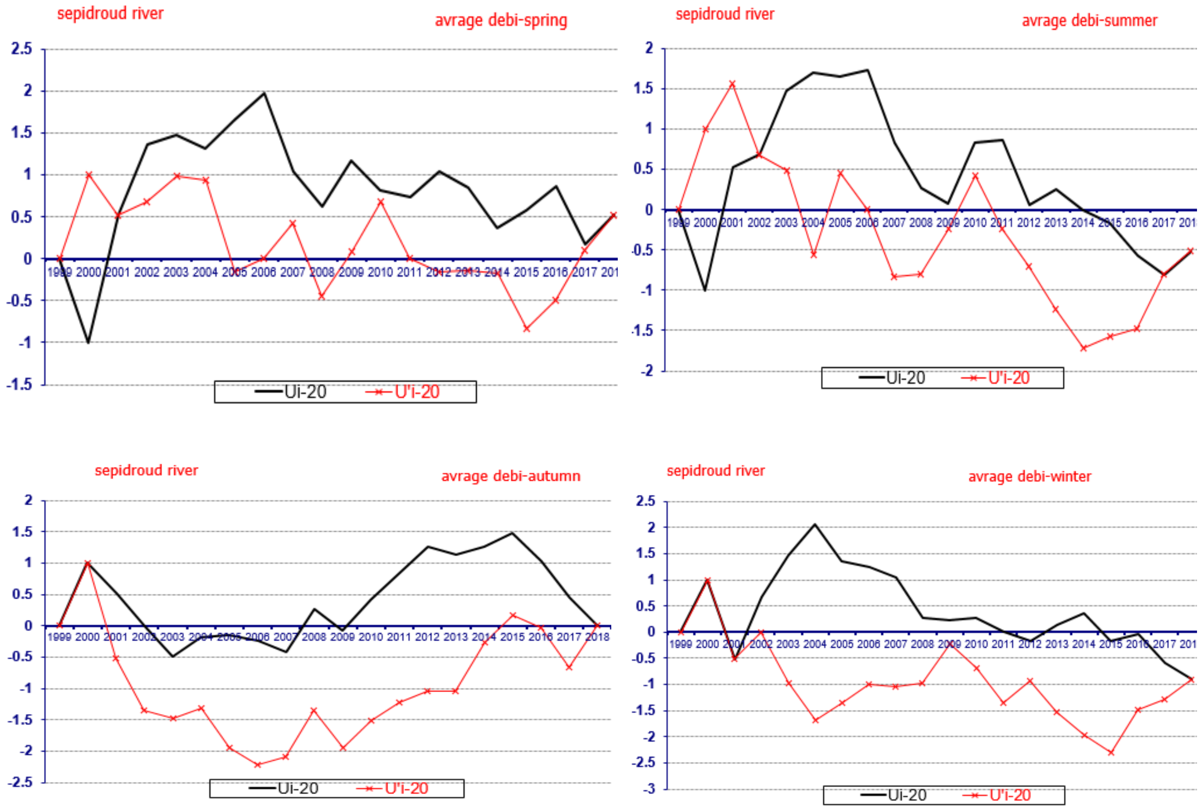


Fig. 8. Results of determining the 20-year average jump points of the average discharge for the Sefidroud River in the studied seasons by the Mann-Kendal ranking method.

In general, comparing the results obtained in the qualitative analysis of the water status of the Sefidroud and Polroud rivers, it was found that the water of the Polrud River is in a stable and good range in terms of agriculture. In contrast, for the Sefidroud River, this situation fluctuates, and in some cases, the water quality for agriculture is out of the excellent range and in the middle range. In explaining the reasons for this issue, it should be stated that the issue of domestic sewage entering Sefidroud has been raised for the past years, because Astaneh Ashrafieh city does not have a central sewage treatment plant. The point to be noted is that the tributaries branching from Sefidroud can indirectly reduce the river's water quality by returning the sewage and toxins entering the Sefidroud River. In general, the effects of human activity (as a major factor) and climate variability (as a secondary factor) have affected the Shahpour River Basin. These effects disrupt the chemical balance of water (the relationship between cations and anions) and hydrological regimes (increased drought stimuli) and thus threaten the health of the watershed (Fooladi *et al.* 2021).

The corrosive nature of the water of these two rivers in different seasons of the year is the existence of houses and agricultural lands near the river, and also the causes of increased nitrate and phosphate in winter are due to agricultural and urban effluents around the river. The point that exists and can affect the actual value of the parameters is that in autumn and winter, compared to spring and summer, the water quality is better because, in these cases, the volume of river water increases due to rainfall, and this factor reduces the effect. Pollutants affect the biological community. Also, the highest amount of palm spraying, which constitutes the majority of the province's agriculture, was done in the spring, which will certainly cause the entry of large amounts of phosphate and nitrate compounds into river water and will affect the water quality of rivers. Fig. 7 shows the results of determining the mean 20-year jump points of the Dubai discharge for the studied seasons by the Mann-Kendal ranking method for the Polrud river station. Charts related to Mann-Kendall were drawn on a seasonal and annual time scale for the Polrud River station, and also the slope of the flow changes trend in the above time series was plotted. Based on the analysis and also the graphs U (ti) and U′ (ti), although there is an increasing linear trend in the annual flow, an increasing or decreasing trend in the statistics of U (ti) in the annual series using the test I do not have a Kendall and it has a static series. On the other hand, the graphs obtained from the Dubai index in the studied station have shown an increasing linear trend. In the quarterly series study, the chart results indicate no trend in the discharge data of each chapter. Fooladi et al. In a study aimed at analyzing the trend of hydrological variables and water quality to identify human effects and climate variability at the scale of Shahpour River Basin by Monkendal test stated that the effects of human activity (as a major factor) and variability Climate (as a sub-factor) has affected the Shahpour river basin. These effects disrupt the chemical balance of water (the relationship between cations and anions) and hydrological regimes (increased drought stimuli) and thus threaten the health of the watershed (Fooladi *et al.* 2021).

Similarly, in Fig. 8, the results of determining the 20-year average jump points of the average discharge for the studied seasons are reported by the Mann-Kendal ranking method for the Sefidroud River station. Table 2 reports the results of the Pearson correlation test for the studied parameters in the Polroud River. This test shows the extent to which there is a linear relationship between quantitative variables. The significance level in the Pearson correlation test for the studied parameters equals 0.05. Where the significance level is higher than 0.05, there is no linear relationship or correlation between the parameters. Where it is less than 0.05, those parameters have a linear relationship and correlation. The results showed that the significance level between the electrical conductivity (EC) parameter and total soluble solids (TDS) is equal to 0.031, which is less than 0.05. Therefore, there is a direct and significant relationship between these two parameters. Evaluating the quantitative and qualitative changes of the Laniangua River in northern Malawi, Wanda and Kyra stated that the relationship between electrical conductivity (EC) and total soluble solids (TDS) is a direct and linear relationship that was consistent with the results of this study (Kayira & Wanda 2010) The researchers said that the relationship between the amount of solid particles such as salt in water and their conductivity is direct, so the larger the particle size, the higher the conductivity, because when the amount of water-soluble particles is high, they ionize. They convert to a positive or negative charge, ultimately directing the flow, and high TDS leads to increased use of calcareous compounds in the river and a direct relationship between electrical conductivity (EC) and total soluble solids (TDS) with pH. The significance level between the EC parameter with a pH of 0.029 and the TDS with a pH of 0.023 is less than 0.05 for both parameters, Mayo et al. Liuzhou River stated that electrical conductivity increases linearly with increasing pH and decreasing acidity, which results in C. This study was consistent (Miao *et al.* 2021).

Table 3 reports the results of the Pearson correlation test for the studied parameters in the Sefidroud River. The results showed that the significance level between the parameter of electrical conductivity (EC) with total soluble solids (TDS) is equal to 0.045, which is less than the Fig. of the significance level of 0.05 and, therefore, a direct and significant relationship between these two parameters. Pant *et al.* (2021), in their study on the "quarantine effects of the coronavirus epidemic on the surface water quality of the Bagmati River Basin in Nepal." Explaining the reasons for this direct relationship, the researchers said that as the amount of water-soluble elements increases, the electrical conductivity increases, and the higher the EC of water, the closer the conversion factor will be to 1, even when the EC is above 20,000. River, the value of the coefficient is greater than 1. This is because the high accumulation of ions in the water has a negative effect on each other, and practically, some ions do not play a role in calculating the TDS. They also stated that the volume of solutes increases. In water, the salinity of water increases, leading to a decrease in water quality. There is a significant level between the EC parameter with a pH of 0.036 and a TDS with 0.029, which is less than 0.05 for both parameters. This result was consistent with the results of Hutchins *et al.* (2018), which examined the "combined effects of climate change factors on water resources and quality in groundwater and surface water of the Upper Thames River Basin in the United Kingdom."

Table 2. Pearson correlation test for the studied parameters over a period of 20 years for the Polroud River

		EC	TDS	PH	Ca	Mg	Na	K	HCO_3	CO_3	Cl	SO_4	Q
EC	Sig.												
	N	80											
TDS	Sig.	0.031											
	N	80	80										
PH	Sig.	0.029	0.023										
	N	80	80	80									
Ca	Sig.	0.038	0.065	0.022									
	N	80	80	80	80								
Mg	Sig.	0.042	0.075	0/036	0.087								
	N	80	80	80	80	80							
Na	Sig.	0.015	0.081	0.064	0.098	0.089							
	N	80	80	80	80	80	80						
K	Sig.	0.024	0.124	0.027	0.031	0.030	0.020						
	N	80	80	80	80	80	80	80					
HCO_3	Sig.	0.049	0.069	0.044	0.022	0.024	0.031	0.031					
	N	80	80	80	80	80	80	80	80				
CO_3	Sig.	0.037	0.077	0.041	0.019	0.066	0.046	0.028	0.064				
	N	80	80	80	80	80	80	80	80	80			
Cl	Sig.	0.026	0.096	0.037	0.033	0.019	0.037	0.046	0.023	0.021			
	N	80	80	80	80	80	80	80	80	80	80		
SO4	Sig.	0.052	0.088	0.073	0.064	0.042	0.044	0.039	0.027	0.031	0.011		
	N	80	80	80	80	80	80	80	80	80	80	80	
Q	Sig.	0.074	0.094	0.068	0.074	0.096	0.097	0.070	0.069	0.091	0.069	0.091	
	N	80	80	80	80	80	80	80	80	80	80	80	80

Table 3. Pearson correlation test for the studied parameters in a period of 20 years for Sefidroud river

		EC	TDS	PH	Ca	Mg	Na	K	HCO_3	CO_3	Cl	SO_4	Q
EC	Sig.												
	N	80											
TDS	Sig.	0.045											
	N	80	80										
PH	Sig.	0.036	0.039										
	N	80	80	80									
Ca	Sig.	0.024	0.046	0.040									
	N	80	80	80	80								
Mg	Sig.	0.034	0.069	0.027	0.060								
	N	80	80	80	80	80							
Na	Sig.	0.022	0.036	0.059	0.084	0.091							
	N	80	80	80	80	80	80						
K	Sig.	0.011	0045	0.037	0.029	0.043	0.018						
	N	80	80	80	80	80	80	80					
HCO_3	Sig.	0.055	0.049	0.071	0.064	0.030	0.052	0.084					
	N	80	80	80	80	80	80	80	80				
CO_3	Sig.	0.037	0.066	0.053	0.044	0.050	0.067	0.033	0.028				
	N	80	80	80	80	80	80	80	80	80			
Cl	Sig.	0.011	0.019	0.084	0.077	0.064	0.039	0.049	0.043	0.028			
	N	80	80	80	80	80	80	80	80	80	80		
SO4	Sig.	0.044	0.069	0.047	0.061	0.082	0.086	0.074	0.037	0.064	0.051		
	N	80	80	80	80	80	80	80	80	80	80	80	
Q	Sig.	0.049	0.082	0.076	0.031	0.016	0.060	0.043	0.055	0.064	0.037	0.079	
	N	80	80	80	80	80	80	80	80	80	80	80	80

The results of comparing the data obtained from the Pearson correlation test for the Polroud and Sefidroud rivers showed that there is a direct relationship between the studied parameters in both rivers in terms of correlation. The significant levels of the two rivers are close to each other, and the results of this test show a difference. The parameters studied in these two rivers do not differ.

CONCLUSION

According to the results, the increase in human activities in the summer period from 1999 to 2018 and the use of agricultural pesticides for spraying the fields and orchards in this season causes large amounts of chemicals to enter the water of the two rivers compared to other seasons. The results of qualitative statistical analysis of the parameters studied in this study for the two rivers of Polroud and Sefidroud showed that in the period from 1999 to 2018 in the summer, the measured parameters have high values compared to other seasons, so the highest arithmetic mean for the index EC in this season is equal to 290.85 for Polroud river and 314.66 for Sefidroud river, TDS index for Polroud river is equal to 246.3 and for Sefidroud river is 277.5 and PH index for Polroud river is equal to 7.65 and for Sefidroud River was 7.79. Also, in the discharge study, it was found that the highest discharge rate for the Polroud River is related to spring, with a rate of 30.82 $m^3 s^{-1}$, and the lowest in summer, with a rate of 10.73 $m^3 s^{-1}$, while the highest discharge rate is for Sefidroud River. In spring, it has a value of 34.43 m3/s; the lowest is in summer, at 32.69 $m^3 s^{-1}$. Also, the study of the significance level of the Pearson correlation test for the studied parameters in Polroud Warehouse showed that the Ca, Mg, Na, and K indices with a significance level of 0.038, 0.042, 0.015, and 0.024, respectively, were directly correlated with the EC index. This is consistent with the results obtained for Sefidroud River that the significance level of Ca, Mg, and Na indices with EC index is equal to 0.024, 0.034, and 0.022, respectively, indicating a direct relationship between them. In general, the results showed that there is not much difference in the qualitative and quantitative changes of the two rivers in the period under study, and the role of the human factor as a common factor in increasing pollution in these two rivers is evident.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

REFERENCE

Akoto, O, Adopler, A, Tepkor, HE & Opoku, F 2021, A comprehensive evaluation of surface water quality and potential health risk assessments of Sisa river, Kumasi. *Groundwater for Sustainable Development*, 15(2): 98-116.

Arain, MB, Ullahb, I, Niazb, A, Shaha, N, Shahb, F, Hussaina, Z, Tariqc, M, Afridid, HI, Baigd, JA & Kazid, TG 2015, Evaluation of Water Quality Parameters in Drinking Water of District Bannu, Pakistan: Multivariate Study. *Sustainability of Water Quality and Ecology*, 3(4): 114-123.

Buss, J & Achten, C 2022, Spatiotemporal variations of surface water quality in a medium-sized river catchment (Northwestern Germany) with agricultural and urban land use over a five-year period with extremely dry summers. *Science of The Total Environment*, 818(13): 296-312.

Dindarlo, K, Alipor, V & Farshidfar, GH 2006, Chemical quality of drinking water of Bandar Abbas. Hormozgan. *Iranian Journal of Medical Sciences*, 62(2): 57-85.

Fooladi, M, Golmohammadi, MH, Safavi, HR, Mirghafari, R & Akbari, H 2021, Trend analysis of hydrological and water quality variables to detect anthropogenic effects and climate variability on a river basin scale: A case study of Iran. *Journal of Hydro-environment Research*, 34(5): 11-23.

Han, S, Hu, Q, Yang, Y, Yang, Y, Zhou, X & Li, H 2019, Response of surface water quantity and quality to agricultural water use intensity in upstream Hutuo River Basin, China. *Agricultural Water Management*, 212(5): 378-387.

Hutchins, M, G, Abesser, C, Prudhomme, C, Elliott, JA, Bloomfield, JP, Mansou, MM & Hitt, OE 2018, Combined impacts of future land-use and climate stressors on water resources and quality in groundwater and surface waterbodies of the upper Thames river basin, UK. *Science of The Total Environment*, 631(5): 962-986.

Jafari, N, Hafezparast, M & Farhadi, B 2021, Qualitative evaluation of water resources for drinking and agricultural uses (Case study: Gamasiab catchment, Kermanshah province). *Environmental Science Studies,* 6 (2): 3525-3532.

Kamasi, M & Sharghi, S 2016, Qualitative evaluation of surface waters and prioritization of effective factors in the pollution of these waters using Topsis fuzzy hierarchical analysis method. *Journal of Environmental Health Engineering*, 4 (2): 184-174.

Li, S, Gu, S, Tan, X & Zhang, Q 2019, Water quality in the upper Han River basin, China: the impacts of land use/land cover in riparian buffer zone. *Journal of Hazardous Materials*, 165: 317-324.

Kayira, F & Wanda, EMM 2021, Evaluation of the performance of Mzuzu Central Hospital wastewater oxidation ponds and its effect on water quality in Lunyangwa River, Northern Malawi. *Physics and Chemistry of the Earth*, 123(5): 103-119.

Miao, X, Hao, Y, Liu, H, Xie, Z, Miao, D & He, X 2021, Effects of heavy metals speciations in sediments on their bioaccumulation in wild fish in rivers in Liuzhou—A typical karst catchment in southwest China. *Ecotoxicology and Environmental Safety*, 214(6): 56-68.

Mirzaei, M, Riahi Bakhtiari, A, Salman Mahini, A & Gholam Ali Fard, M 2015, Modeling the Relationship between Surface Water Quality and Landscape Measurements Using Neuro-Fuzzy Inference System (Case Study: Mazandaran Province). *Journal of Water and Wastewater*, 27 (1): 81-92.

Motamedi Rad, M, Goli Mokhtari, L, Bahrami, S & Zanganeh Asadi MA 2021, Evaluation of water resources quality in terms of drinking, agriculture and industry in Rouin Esfarayen karst aquifer of North Khorasan province. *Journal of Applied Research in Geographical Sciences*, 21 (62): 73-93.

Pant, RR, Bishwakarma, K & Qaiser, FUR 2021, Imprints of COVID-19 lockdown on the surface water quality of Bagmati river basin, Nepal. *Journal of Environmental Management*, 289, 455-463.

Ramachandran, A, Krishnamurthy, RR, Jayaprakash, M & Shanmugasundharam, A 2019, Environmental impact assessment of surface water and groundwater quality due to flood hazard in Adyar River Bank. *Acta Ecologica Sinica*, 39(2): 125-133.

Treiblmaier, H & Filzmoser, P 2010, Exploratory factor analysis revisited: How robust methods support the detection of hidden multivariate data structures in IS research. Information & Management, 47(2):197-207.

Yang, L, Li, J, Zhou, K, Feng, P & Dong, L 2021, The effects of surface pollution on urban river water quality under rainfall events in Wuqing district, Tianjin, China. *Journal of Cleaner Production*, 293(8): 126-132.

Zahedi, M, SariSaraf, B & Jameei, J 2006, Rain modeling in Tabriz and Oroumiyeh stations. *Journal of Geography and Regional Development*, 7(5): 1-16.