

Table 2. The results of Kruskal Wallis statistical test for each qualitative parameter since the periods before and after constructing Jarreh dam

Station	River/ Dam	Constituent	p-value	Decision
Kruskal Wallis Test				
polmanjanigh	RoudZard/ Jarreh Dan	Cl	0.109	ND
		SO ₄	0.092	ND
		EC	0.118	ND
Mashin		Cl	0.000	SD
		SO ₅	0.000	SD
		EC	0.81	ND

Note: ND, no difference; SD: significantly different 95% confidence level

T-test and Kruskal-Wallis test (Table 3) showed that a difference was found in chlorine and sulfate ions in some of the quality monitoring stations in Marun and Roudzard rivers. Cl⁻ and SO₄²⁻ parameters before and after dam construction were significantly different at Behbahan and Cham Nezam stations at the downstream of reservoir dam (P<0.05). Also, Mashin station at the downstream of Jarreh Dam had significantly different concentrations of sulfate and chlorine ions before and after the dam construction. No significant difference was found at the upstream stations of Marun and Jarreh dams considered as the only basis for the changes and did not have a significant effect on the purpose of the study. Only by analyzing the load values of downstream stations can we comment on the purpose of the study. The significant differences in the concentration of chlorine and sulfate ions are due to the effects of various factors, mainly due to the effects of the geological formation of the area and the agricultural lands along the river margin.

3.2. Data analysis

According to the graphical analysis shown in Fig. 2, it can be concluded that the magnitude of the fluctuations in the period after the construction of each of Marun and Jarreh reservoir dams in each of the statistical periods (2001-2018 and 2012-2018) for all stations is much smaller than the period before constructing the dam (1977-1997 and 1977-2010).

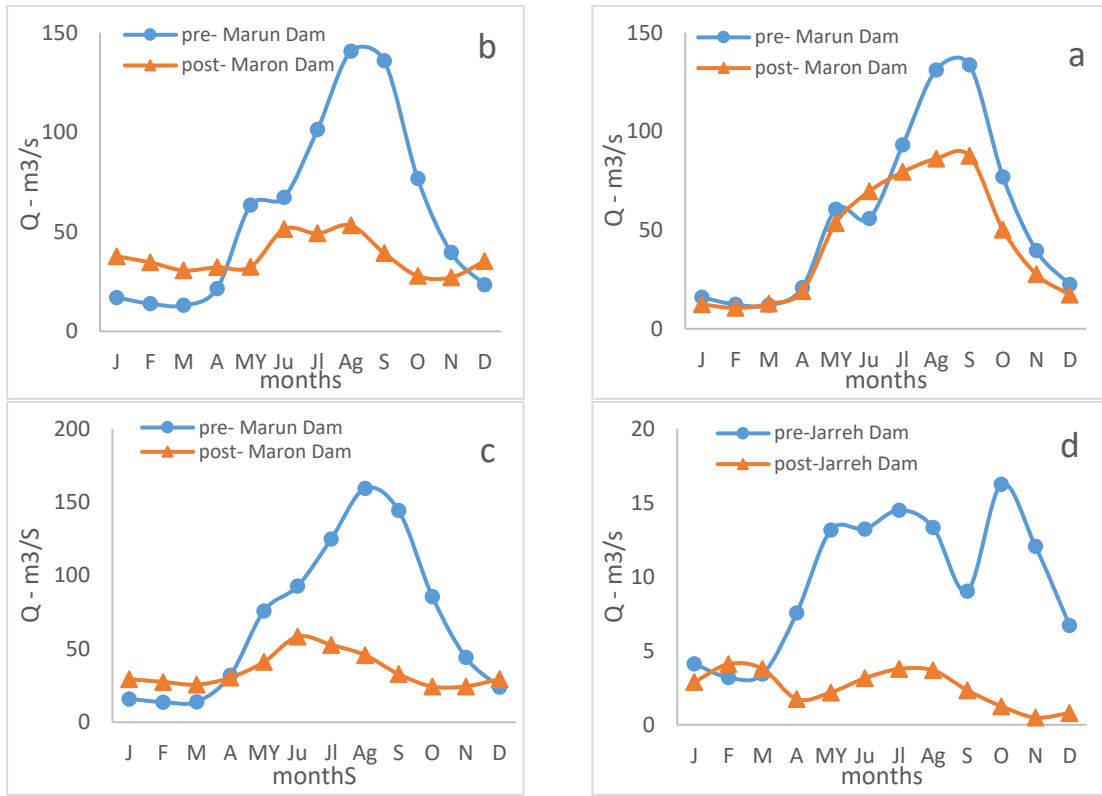


Figure 2. Monthly discharge in hydrometric Stations in Marun and Roudzard Rivers Before and After constructing Dams (a: Eydanak, b: Bebahan, c: Cham Nezam, d: Mashin)

A set of concentrations of water quality constituents including electrical conductivity (EC), chlorine (Cl^-) and sulfate (SO_4^{2-}) at each of the upstream and downstream water quality monitoring stations in Marun and Zard rivers over a period of 40 years. 1977 to 2018 is shown in Figure 3.

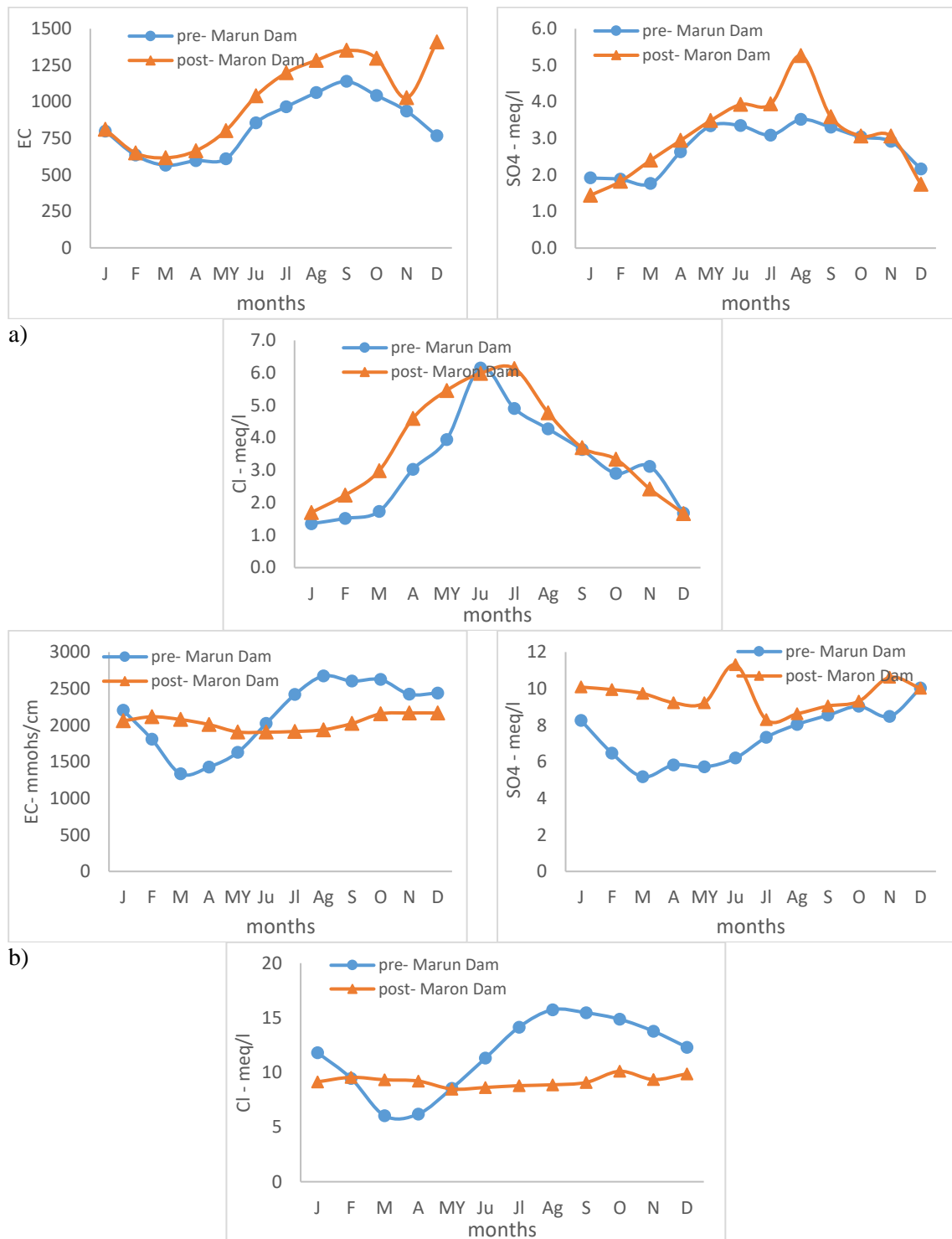


Figure 3. Monthly time series of concentration values of water quality parameters at Marun and Roudzard rivers stations in statistical periods before and after constructing dams (a: Eydanak, b: Behbahan)

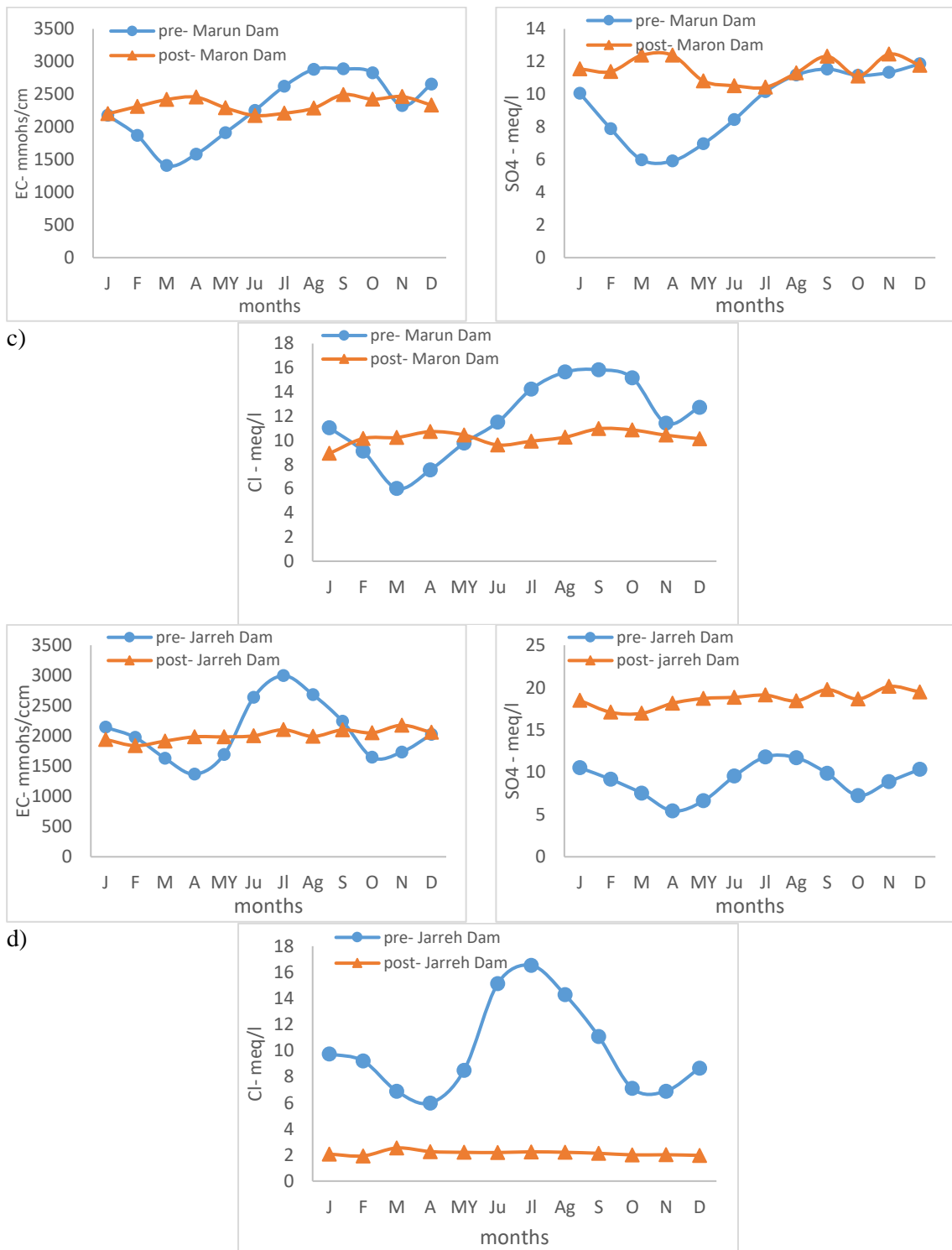


Figure 4. Monthly time series of concentration values of water quality parameters at Marun and Roudzard rivers stations in statistical periods before and after constructing dams (c: Cham Nezam, d: Mashin)

According to Figures 3 and 4, it can be stated that the concentration values of water quality parameters at each of the qualitative monitoring sites in the statistical periods before and after constructing the dam show, however, that the periods after constructing the dam have been uniform but the periods before constructing the dam there have been more fluctuations. There are several reasons for these changes. The range of the concentration fluctuations at the downstream stations of the dam is greater than the concentration values at the upstream stations (Fig. 3a). Some of them may depend on the flow changes and season condition.

All data are more uniform than the period before constructing the dam, and this may reflect the effect of the reservoir on water quantity (Fig. 2) and quality (Fig. 3 and 4). Under optimum conditions and before constructing the dam, as shown in each of the values of the concentration of qualitative parameters at the studied stations, the increase in flow causes dilution of the concentration of the parameters and consequently reduces the concentration value of the parameters at a specific time when the discharge is increased. However, in some cases increasing discharge does not reduce or dilute the concentration of qualitative parameters and is influenced by various factors such as the relationship between more geological layers along the river flow path with higher discharges, increasing the concentration of water quality. For this purpose, as shown in Figures 2, 3 and 4, for the concentration values of the qualitative parameters before and after dam construction we can say:

Study of the period before dam construction: At Eydanak station, EC parameter concentration affected by geological and agricultural factors has increased with increasing flow rate in different months. Similarly, for sulfate concentration values, the main reason for the increase with increasing flow in the period before dam construction was the relationship between the geological layers and the passing flow. At the downstream of Marun Reservoir Dam at Behbahan station, the same situation applies to Eydanak station. At Cham Nezam station, as the last qualitative monitoring point of the river at the downstream of the dam and Behbahan station, pre-construction conditions and trend changes in concentration of water quality parameters continued and were similar to its upstream station i.e. Behbahan. Also, in Roudzard River before the construction of Jarreh Dam, the concentration of Mashin station parameters increased due to geological layers in the river bed and the relationship between the river flow and the formation.

Study of the period after dam construction: At Eydanak station at the upstream of Marun Dam, the conditions of dam construction have no effect on the variability of water quality parameters of the station, but it is clear that in the period after dam construction, even with reducing the river flow parameters increased that is probably affected by successive droughts, and the increase has been attributable to the effect of geological formations of the study area and upstream agricultural activities. At Behbahan station, studied water quality parameters reduced after Marun Dam construction due to water storage in the reservoir, but EC, SO_4^{2-} and Cl^- values increased and have been stable. This is due to the effect of formations due to seasonal conditions and runoff production in the basin and the discharge rate of the reservoir flow related to the geological layers of the area. The changes in concentration values of water quality parameters at Cham Nezam station after construction of Marun Dam indicate that with reducing flow rate similar to the condition of Behbahan station, water quality parameters of Cham Nezam station continued to be uniform and constant. The study of Mashin station state in the period after Jarreh Dam construction showed that by reducing the flow rate, the electrical conductivity became uniform and steady compared to before the construction of the dam.

The statistical data including the maximum, average, minimum, and standard deviation values for concentrations of water quality constituents in the periods before and after the construction of

each of the catchment dams at the monitoring stations are shown in Table 3.

According to Table 3 and examining the ratio of maximum to minimum concentrations of water quality constituents, the highest ratio before the construction of the dam at each of Marun River Monitoring Stations was related to chlorine ion (32/93), which was decreasing from upstream to downstream (Cham Nezam station). Also, the calculated ratio of sulfate downstream increased in this study. In the post study, the highest ratio of maximum to minimum values of concentration of each of the parameters is related to the sulfate ion (49) and the lowest value of the ratio of maximum to minimum values is related to electrical conductivity. The source of the abundance of sulfate in the river is due to the dissolution of gypsum due to the geological structure of the area and the aforementioned Gachsaran formation. Also, the source of chlorine concentration in the river may be due to agricultural activities, rain water and evaporite deposits.

Table 3. Statistical Parameters of Water Quality Concentration Values from Statistical Periods before and after Marun and Jarreh Dams at Each Quality Monitoring Station

Station	Constituent	n	Max	Min	Mean	SD	Median	R(Max/Min)
for concentration values from 1979 to 1999 (pre-Marun dam)								
Eydanak	Cl ⁻	252	24.7	0.75	3.18	2.19	2.86	32.93
	SO ₄	252	8.29	1.03	2.74	1.06	2.58	8.05
	EC	252	2850.0	350.0	831.03	269.04	794.50	8.14
Behbahan	Cl ⁻	252	28.0	1.45	11.64	4.65	11.95	19.31
	SO ₄	252	26.25	2.60	7.43	2.93	7.00	10.10
	EC	252	4130.0	830.0	2117.43	592.37	2134.80	4.98
ChamNezam	Cl ⁻	252	26.50	1.65	11.66	4.47	11.98	16.06
	SO ₄	252	23.28	1.92	9.37	3.41	9.02	12.13
	EC	252	3925.0	970.0	2283.25	658.44	2291.50	4.05
for concentration values from 2002 to 2019 (post-Marun dam)								
Eydanak	Cl ⁻	216	11.71	0.58	3.74	2.03	3.36	20.19
	SO ₄	216	14.30	0.55	3.06	1.78	2.86	26.00
	EC	216	9711.0	339.80	1012.59	683.93	909.50	28.58
Behbahan	Cl ⁻	216	16.13	2.94	9.20	2.42	9.28	5.49
	SO ₄	216	51.05	1.04	9.62	3.54	9.36	49.09
	EC	216	2942.0	845.00	2036.30	352.06	2067.50	3.48
Cham Nezam	Cl ⁻	216	16.04	1.63	10.22	2.28	10.10	9.84
	SO ₄	216	21.17	4.79	11.54	2.39	11.20	4.42
	EC	216	3408.00	1045.00	2338.87	412.56	2286.00	3.26
for concentration values since 1979 to 2011 (pre-Jarreh dam)								
Mashin	Cl ⁻	396	38.82	0.65	9.89	5.70	8.60	59.72
	SO ₄	396	19.62	3.4	9.05	2.97	8.735	5.77
	EC	396	5778.0	696.0	2051.90	734.04	1932.50	8.30
for concentration values since 2013 to 2019 (post- Jarreh dam)								
Mashin	Cl ⁻	84	5.26	0.98	2.15	0.48	2.13	5.37
	SO ₄	84	24.16	12	18.64	2.33	19.1	2.01
	EC	84	2640.0	1450.0	2011.9	238.4	2000.0	1.82

Regarding the mean concentrations of water quality constituents in the period before and after constructing the dam shown in Table 1, the percentage of changes in the mean quality parameters in each position of water quality monitoring stations is shown in Table 4. As shown in Table 4, the values of concentration changes of water quality parameters studied are decreasing and increasing. The concentration values of quality parameters in Marun River at Eydanak station before constructing Marun Dam were reduced in all parameters but to determine

the effects of dam construction on downstream water quality as shown in the Table, at Behbahan station percentage change in quality parameters before and after the dam construction, sulfate ion concentration (SO_4^{2-}) was reduced by 30% and chlorine (Cl^-) and electrical conductivity (EC) concentrations increased by 21 and 4%, respectively, due to the effects of the downstream geological formations as well as outflows from power plants and seasonal conditions. Also at Cham Nezam station, which is located downstream of Marun Dam and after Behbahan irrigation and drainage network, the changes in SO_4^{2-} and EC concentration values reduced compared to before the dam construction and percentage of Cl^- concentration changes increased by 12% that is due to major agricultural activities prior to the quality monitoring station and the entry of agricultural drains into the river. The ratio of changes in concentration of water quality parameters in Roudzard River under the influence of Jarreh Dam in the two studied periods showed that the trend of changes in sulfate ion concentration was significantly reduced by 106% due to control and improvement of the effects of downstream sulfate concentration after the dam construction. Chlorine and electrical conductivity changes after the dam construction are also increasing, with a significant 78% increase in chlorine content, which may be due to climatic conditions due to the entry of outflow drains of agricultural activities and the discharge output of Jarreh reservoir directly related to the regional geological formation.

Table 4. Changes in water quality concentration parameters at the studied stations

Station	River	Constituent	Change% $((\bar{X}_{Post} - \bar{X}_{Pre}) / \bar{X}_{Pre}) * 100$
Eydanak	Marun	Cl^-	-18
		SO_4^{2-}	-11
		EC	-22
Behbahan	Marun	Cl^-	21
		SO_4^{2-}	-30
		EC	4
ChamNezam	Marun	Cl^-	12
		SO_4^{2-}	-23
		EC	-2
Mashin	RoudZard	Cl^-	78
		SO_4^{2-}	-106
		EC	2

4. Conclusion

Sulfate ions are potentially derived from natural sources such as geological layers. Sulfate concentrations in natural waters are less than 80 mg / l (2.2 mEq per liter) but in places near discharge of industrial effluents or areas where gypsum-rich geological conditions are even higher than 400 11 mg / L (11 mEq / L). The high concentration of sulfate ions at the stations indicates the existence of gypsum formations along the river path and the main reason for the

entry of agricultural water and geological formations within the reservoir dams. Also, it has a direct relationship with the amount of discharge that reduced in the river in low flow rate months. Chlorine is also one of the constituents that its concentration increases in water resources in proportion to the growth of the human community. Its sources can be geological layers, industrial effluents (plants), pesticides and agricultural activities, and even atmospheric sources such as rainfall. Regarding the fatal effects of high concentrations of chlorine on aquatic life as well as the carcinogenic effects of water on humans, chlorine has become one of the important indices of surface water quality evaluation.

According to the results and studies conducted on the evaluation of the geological formation of the area, which is mainly Gachsaran formation, as well as the activities of the riverfront agricultural lands, in general these factors can have different effects during the pre- and post-reservoir periods on the quality of river water flow so that before constructing reservoirs due to atmospheric conditions in different seasons and high outcrop (exposure) of geological formations affected by these atmospheric conditions such as rainfall at basin level runoff is produced due to formations and flow rate increased as the downstream flow increased the outcrop of the layers increased and river water quality reduced. Therefore, under climate and seasonal conditions water quality reduced and the concentration of the studied qualitative parameters increased. However, during post-construction and filling of the reservoir, the dam reservoir location can cause involvement of the formation with the reservoir and combined with different qualities caused by atmospheric precipitation and snowmelt, thus after the dam construction formations cannot have much relationship with the flow rate because it is discharged from the reservoir due to the downstream needs. Also, regarding agricultural activities and their effects on the river by comparing the concentration values of qualitative parameters under the station conditions, water quality changes under the influence of Behbahan irrigation and drainage network on the river margin are higher than before the dam construction, because after filling Marun Dam, the agricultural lands and activities are developed and the agricultural drainage affects the river, increasing the concentration of water quality parameters in the river. Therefore, it can be concluded that water quality characteristics of Marun and Roudzard rivers in the studied basin have been affected by the constructed reservoir dams.

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