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WATER QUALITY IN THE RESERVOIRS OF SEASONAL RIVER DAMS

Human activities, such as sewage discharge and the use of fertilizers in agricultural lands resulted in reduced surface water quality worldwide. This study aimed to investigate water pollution in the Ghadruni Dam in the reservoirs of a seasonal river dam. Large amounts of chemical fertilizers used on the lands around the seasonal rivers as well as their runoff from agricultural lands may affect water quality more significantly than that of permanent rivers. Measurements of dissolved solids, temperature, electrical conductivity (EC), pH, turbidity, chloride, sulfate, nitrite, nitrate, ammonium, dissolved oxygen (DO), chemical oxygen demand (COD), and nitrogen were taken for a year. The results indicate that the main cause of pollution in the dam basin is from agricultural effluents, as well as domestic and industrial sewage that is discharged into the system.

1. INTRODUCTION

In areas with high rainfall, rivers are typically permanent, while in areas with low rainfall, they are often dry throughout the year, which are referred to as dry rivers, resulting in two types of rivers: permanent and seasonal [1]. Although seasonal rivers may have a relatively lower economic value, new advancements in river engineering have identified many unknown values of these waterways. The type of flow in seasonal rivers differs from that of permanent rivers and is highly dependent on the amount and trend of

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sediment movement [1]. Human activities such as wastewater discharge and the use of fertilizers in agricultural lands resulted in reduced surface water quality worldwide [2].

Due to various factors, the deterioration of surface water quality caused significant damage to agricultural, drinking, industrial, and recreational areas [3, 4]. On the one hand, urbanization has resulted in the development of surface impermeable coatings, leading to increased waste and decreased water quality [5]. On the other hand, the 21st century is known as the century of water stress or hydrological stress [6], and water quality is a critical issue directly related to public health, with its significance being acknowledged by everyone. Responsible organizations aim to manage water resources properly and increase awareness of water quality and pollution. The availability of tools such as chemical and biological knowledge and an understanding of ecological characteristics can contribute to achieving such goals [7, 8].

Water quality monitoring plays a critical role in the development and evaluation of watershed management policies. According to the laws of water quality management in Iran, monitoring should be both continuous and periodic [9]. This, in turn, helps identify pollution and its compliance with standards and establishes a reliable monitoring system to reduce pollution effectively [10]. By studying changes in waterway and dam reservoir pollution, pollution sources can easily be identified. By discovering pollution in the rivers and reservoir lakes of the Ghadruni Dam basin, we can determine its causes and find solutions to manage pollution effectively. The concentrations of pollutants in rivers leading to dams and multiple discharges are significantly affected by factors such as rainfall, surface runoffs, surface flows, groundwater, and outflows [11]. It must be noted that increasing the entrance of organic materials and phosphorus concentration reduces organic material content [12].

Fertilizers left in the basin are also a contributing factor to water pollution [13]. The use of fertilizers for agricultural purposes results in their entry into the dam river and inlet. Accordingly, a deep understanding of the chemical and biological properties of rivers seems to be essential for any effective long-term management [14]. Although a bulk of studies have been conducted on the discharge changes of water in seasonal rivers in this dam, no research has hitherto focused on the pollution of the water entering the basin. This study aims to evaluate the number of water pollutants to provide future management strategies [15] and is conducted in compliance with Iranian water regulations. Previous studies have primarily focused on evaluating pollution samples taken from rivers, especially within reservoirs. However, no comprehensive research has been conducted in the basin of this area, leading to a lack of serious investigation and elimination of pollution problems. The dam under study is located in a relatively low-water area and is a crucial source of watering and artificial moisture. Therefore, a comprehensive monitoring plan appears to be necessary to develop sustainable solutions to pollution problems [16].

In this study, we addressed the level of pollution in two streams of the region with an area of about 441 km^2 (44 000 ha) (Fig. 1).

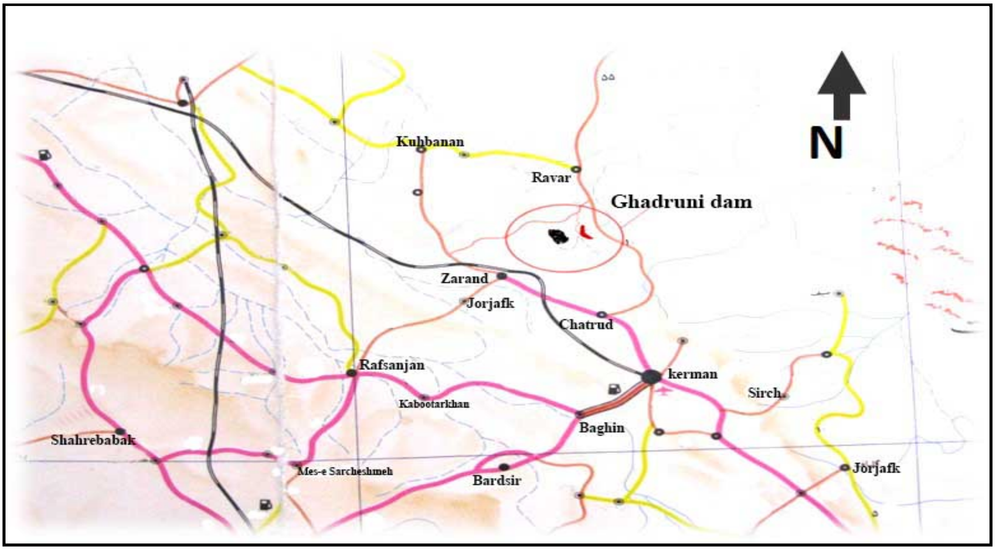

Fig. 1. Geographical position and ways to access the location of Ghadruni Dam

Figure 2 shows the location of the sampling stations. The distribution of lands in this studied area is about 37 200 ha of pastures, 2200 ha of agriculture and housing, 800 ha of industry, and 4800 ha of forests (Table 1). The yearly average rainfall of this area is 286 mm. It has a relatively dry climate. The average annual temperature of this region is 14.5 °C (Kerman Province Water and Regional Organization).

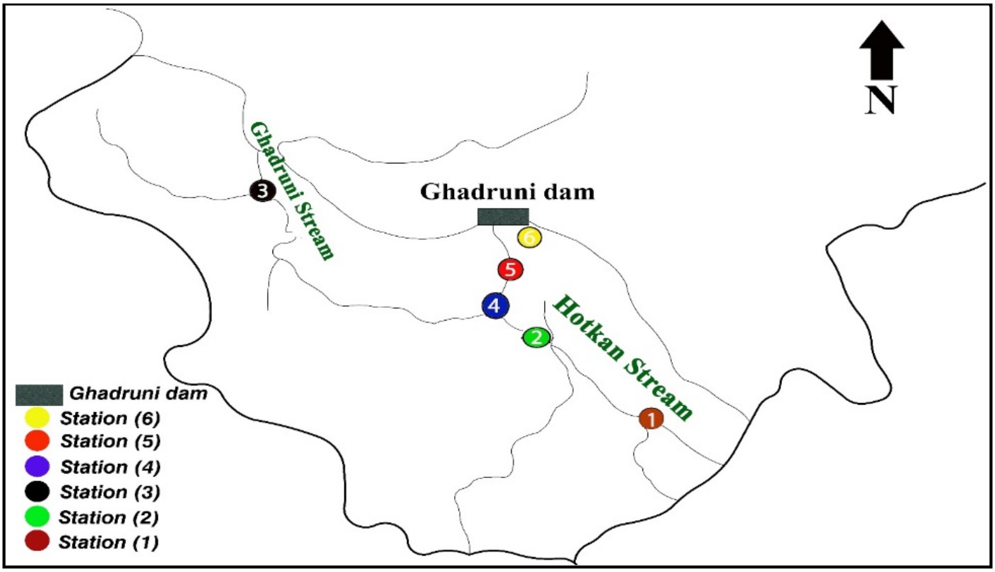

Fig. 2. Site water sampling Ghadruni Dam

Table 1

Land use types around sampling locations

Sampling location	Land use types
1	agriculture + residential + pasturage + industry
2	agriculture + pasturage + pasturage
3	agriculture + pasturage + industry
4	agriculture + residential + pasturage
5	agriculture + residential + pasturage
6	agriculture + grassland + residential + pasturage

Fig. 3. Some water sampling Ghadrooni Dam

Ghadruni Dam is on two main streams of the Ghadrun and Hotkan Rivers in a flat and residential area. The main objectives of this dam are to supply drinking water to the two cities of Zarand and Ravar, as well as to serve agricultural and industrial purposes in this area. Other purposes of constructing this dam have been to protect residential areas and to store floods and seasonal floodwaters [17] (Fig. 3). Also, this dam hosts the migration of birds less seen in the dry and waterless province of Kerman. In this study, we strive to determine the other prominent characteristics of this dam. Moreover, some solutions are provided to evaluate the pollution of the Ghadruni Dam basin by determining pH, total dissolved solids (TDS), electrical conductivity (EC), temperature (*T*), turbidity, nitrate, nitrite, sulfate, chloride, ammonium, dissolved oxygen (DO), chemical oxygen demand (COD), and nitrogen parameters.

2. MATERIALS AND METHODS

The area under study is in the basin of Ghadruni Dam on the border of Zarand and Ravar cities in Kerman Province between 56°50′50″ longitude and 30°57′43″ latitude (Fig. 1). Six sampling stations in the reservoir and connected streams to the basin were selected (Fig. 2). Water samples were taken from the Ghadrun and Hatkan streams and the dam reservoir. However, field observations revealed other streams upstream of the basin, which do not reach the mainstream (Fig. 2). Water samples were taken from a depth of 10 to 15 cm and collected in one-liter bottles. The samples taken bi-monthly from the sampling stations from 2019 to 2020 were transferred to a quality control laboratory for one year and under cold conditions. Electrical conductivity (EC), pH, temperature, turbidity, dissolved solids, ammonium, chloride, sulfate, nitrite, nitrate, COD, DO, and nitrogen were analyzed for one year. pH was measured with an electrometer device. Turbidity was measured by a nephelometry turbidimetry device. All dissolved solids were tested by the standard methods [18]. Electrical conductivity was measured by an electrometer device [18]. The concentrations of sulfate, nitrite, and nitrate were determined by the spectrophotometer device. Chloride and hardness were analyzed using the titration device. Statistical analysis of the obtained results was performed with the use of SPSS software.

3. RESULTS

Descriptive statistics were compiled according to Table 2. The samples collected were analyzed and evaluated using SPSS software. They were complied with Iranian water quality management regulations (Tables 3–7).

Table 2

Descriptive statistics of yearly chemical and physical parameters of total stations (N = 36 mg/dm^3)

Parameter	Minimum	Maximum	Mean	Std. deviation
EC, mS/cm	480	3360	991.25	701.10
TDS, mg/dm^3	233	1725	505.13	364.04
pH	6.50	8.50	7.44	0.5456
Turbidity, NTU	0.26	37.67	4.33	6.81
SO_4^{2-}, mg/dm^3	8	870	271.50	235.68
NO_3^-, mg/dm^3	3.7	29	13.95	6.63
NO_2^-, mg/dm^3	0.004	2.50	0.337	0.652
Cl^-, mg/dm^3	15	455	114.68	124.75
Temperature, °C	6.50	29.50	17.63	7.48
COD, mg/dm^3	51	987	326.41	302.45
NH_4^-, mg/dm^3	0.90	3.50	2.22	0.773
Total N, mg/dm^3	57	408	197.027	100.54
DO, mg/dm^3	1.10	10.48	4.44	2.73

Table 3

Descriptive statistics of yearly chemical and physical parameters of all six stations

Parameter		Station					
		1	2	3	4	5	6
EC, mS/cm	Mean	872.666	741.666	1196.666	1199.666	817.166	1119.666
	Std. dev.	286.344	234.615	1079.341	820.202	246.088	1074.720
TDS, mg/dm^3	Mean	426.333	400.666	592.333	589	437.500	585
	Std. dev.	127.173	203.919	562.376	407.473	138.206	563.270
pH	Mean	7.898	7.540	7.103	7.440	7.598	7.088
	Std. dev.	0.4132	0.5185	0.3864	.3372	.7740	0.4515
Turbidity, NTU	Mean	1.880	10.053	2.876	3.7133	2.263	5.226
	Std. dev.	0.6792	14.030	2.9327984	2.3382	1.799	7.405
SO_4^{2-}, mg/dm^3	Mean	192.833	128.83	255.166	354	291.166	407
	Std. dev.	112.929	87.864	288.822	231.205	191.484	363.304
NO_3^-, mg/dm^3	Mean	11	11	13	13.750	17.283	17.666
	Std. dev.	4.732	4.289	8.173	3.282	10.783	4.676
NO_2^-, mg/dm^3	Mean	0.063333	0.0250	0.5983	.172167	.638	.525
	Std. dev.	0.05316	0.0083	0.9061	.356	1.036	.6946
Cl^-, mg/dm^3	Mean	108.666	80.416	123.750	156.583	60.083	158.583
	Std. dev.	109.344	70.647	164.709	177.769	31.594	150.709
Temperature, °C	Mean	16.833	17.250	18	17.750	17.333	18.666
	Std. dev.	7.985	8.208	7.429	8.519	8.286	7.846
COD, mg/dm^3	Mean	145.583	272.250	197.166	313.833	533.250	496.416
	Std. dev.	95.972	298.487	149.823	292.859	358.881	394.985
NH_4^-, mg/dm^3	Mean	2.280	2.270	2.300	2.200	2.183	2.125
	Std. dev.	0.7262	1.124	0.68117	.7563	.899	0.7250
Total N, mg/dm^3	Mean	176.666	177.666	226.333	185.500	181.833	234.166
	Std. dev.	110.695	60.944	130.619	67.0246	101.359	137.476
DO, mg/dm^3	Mean	5.308	4.746	5.511	4.225	3.333	3.541
	Std. dev.	3.274	3.065	3.327	2.320	2.446	2.257

Table 4

Average seasonal chemical and physical parameters of all stations

Station	1	2	3	4	5	6
EC, mS/cm	862.50	731.13	1131.63	1081.75	831.50	1024.13
TDS, mg/dm^3	412.25	385.63	559.38	531.63	427.00	526.00
pH	7.80	7.66	7.17	7.47	7.46	7.11
Turbidity, NTU	1.76	9.02	2.90	3.88	2.67	4.97
SO_4^{2-}, mg/dm^3	175.63	131.38	234.88	303.50	266.50	365.25
NO_3^-, mg/dm^3	11.38	11.00	11.38	13.31	16.05	18.63
NO_2^-, mg/dm^3	.050	.026.	.453	134	.483	.525
Cl^-, mg/dm^3	84.89	70.25	56.07	83.80	48.94	101.06
Temperature, °C	14.75	15.19	16.13	15.56	15.38	16.81

Table 4

Average seasonal chemical and physical parameters of all stations

COD, mg/dm^3	123.13	220.13	161.50	256.25	437.94	411.88
NH_4^-, mg/dm^3	2.09	1.93	2.15	2.08	1.99	1.98
Total N, mg/dm^3	147.13	159.13	181.13	169.00	170.13	200.00
DO, mg/dm^3	6.33	5.60	6.57	4.88	4.06	4.13

Table 5

Correlation between chemical and physical parameters

	EC	TDS	pH	Turbidity	SO_4^{2-}	NO_3^-	NO_2^-	Cl^-	*T*	COD	NH_4^+	N	DO
EC	1												
TDS	0.983**	1											
pH	–0.697	–0.799	1										
Turbidity	–0.351	–0.264	–0.149	1			–						
SO_4^{2-}	0.696	0.763	–0.562	–0.366	1								
NO_3^-	0.248	0.377	–0.461	–0.262	0.811	1							
NO_2^-	0.353	0.445	–0.604	–0.433	0.554	0.779	1						
Cl^-	0.859*	0.844*	–0.538	–0.112	0.664	0.141	–0.007	1					
T	0.720	0.829*	–0.936**	0.071	0.771	0.626	0.572	0.681	1				
COD^3	–0.052	0.098	–0.294	0.022	0.622	0.923**	0.583	–0.082	0.451	1			
NH_4^-	–0.190	–0.311	0.313	0.025	–0.818*	–0.873*	–0.386	–0.322	–0.580	–0.886*	1		
Total N	0.687	0.765	–0.905*	–0.080	0.575	0.467	0.645	0.583	0.903*	0.208	–0.293	1	
DO	0.079	–0.053	0.149	–0.023	–0.630	–0.864*	–0.411	.033	–0.356	–0.972**	0.925**	–0.053	1

*Correlation significant at the 0.05 level (2-tailed).
**Correlation significant at the 0.01 level (2-tailed).

Table 6

Some of the regulations and standards for drinking water in Iran and WHO

Parameter	Level		Parameter	Level	
	Normal	Allowed		Normal	Allowed
EC, mS/cm	1000	2000	NO_2^-, mg/dm^3	0/01	0/03
TDS, mg/dm^3	500	2000	Cl^-, mg/dm^3	200	600
pH	5/7–87	6/5–9	NH_4^-, mg/dm^3	0/05	1/5
Turbidity, NTU	1	5	Total N, mg/dm^3	1	3
SO_4^{2-}, mg/dm^3	250	400	DO, mg/dm^3	70	30
NO_3^-, mg/dm^3	50	50			

Table 7

Wastewater flux after each rainfall in different seasons

Season	Spring	Summer	Autumn	Winter
Q, m^3/s	0.032	0.030	0.026	0.024

Also, using the diagrams, we can analyze the seasonal changes and the percentage of increase and decrease of the parameters. The trend of changes in the parameters along the river and the location of the stations are observed.

4. DISCUSSION

4.1. ELECTRICAL CONDUCTIVITY

The average EC at the sampling stations was between 817 and 1199 mS/cm (Table 3). The values for the sixth and fourth stations are higher than those for the other sampling stations (Fig. 4) due to the rich variety of mineral salts [19]. The status of mineral pollution with changes in EC indicates that agricultural runoff and wastewater inlets into the dam's lake increase EC [20] (Table 7). Due to the reduction of sediments, EC values at station 2 are lower than those of other stations.

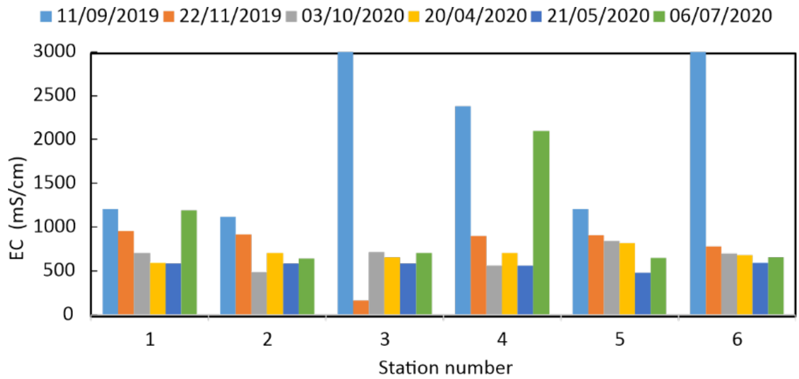

Fig. 4. Mean EC measured at six stations within 6 periods of time

The average EC value observed at the lowest level in spring was about 480 mS/cm and the highest one in summer was 3360 mS/cm (Table 2). EC values in summer and autumn are higher than those in spring and winter due to increased evaporation. In sampling stations during the spring and winter seasons, an increase in sediments leads to an increase in the electrical resistance of water, which results in decreased electrical conductivity. Also, the discharge of effluents from the irrigation of agricultural products is also effective in increasing EC and influences the water resources of the lake dam.

EC changes depend on the evaporation and wastewater inlets. High EC values reported in some stations in different seasons in Ghadruni Dam lakes are not appropriate for irrigation.

According to the correlation matrix, EC is directly related to dissolved solids and chloride (Fig. 5).

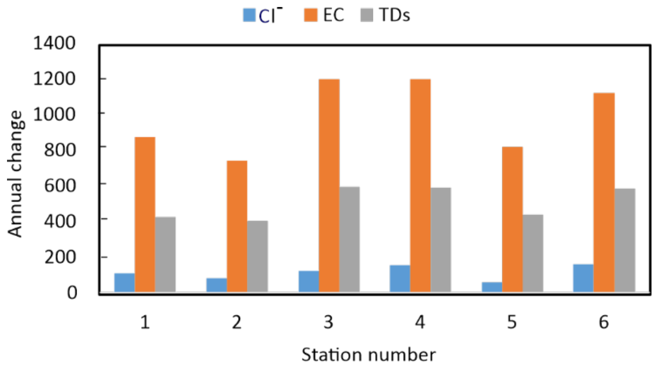

Fig. 5. Mean annual changes of EC, TDS, and Cl^-

4.2. TOTAL DISSOLVED SOLIDS (TDS)

The average TDS values at the sampling stations were between 400.66 and 592.3 mg/dm^3 (Table 3). Due to the presence of more wastewater at the third sampling station, the values of TDS increased compared to other stations. According to the data obtained from the average TDS, the concentration of TDS increases from spring to summer whereas it decreases from autumn to winter (Fig. 6).

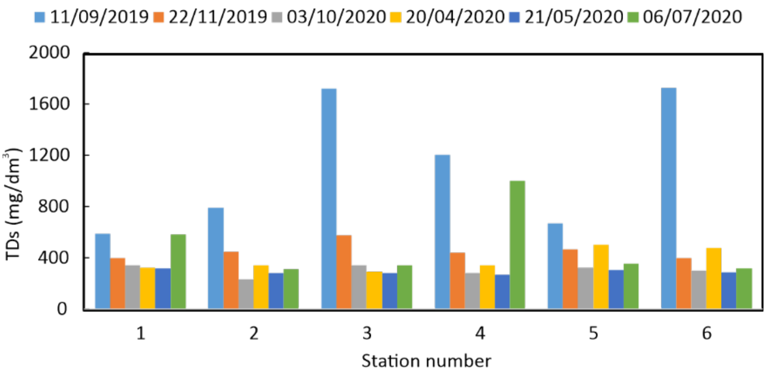

Fig. 6. Mean TDS measured at six stations within 6 periods of time

Seasonal changes of TDS in warm seasons are higher than those in other ones. Spring and summer rainfalls carrying sediments affect the concentration of dissolved solids, thus the TDS parameter positively correlates with EC, chloride, and temperature parameters (Table 5).

4.3. pH

The average pH values were between 7.47 and 7.80 at the sampling stations (Table 4) with the highest ones at station 5. The pH values at the stations did not differ significantly from each other. According to seasonal assessments, pH was 6.5 in autumn and 8.50 in summer (Table 2).

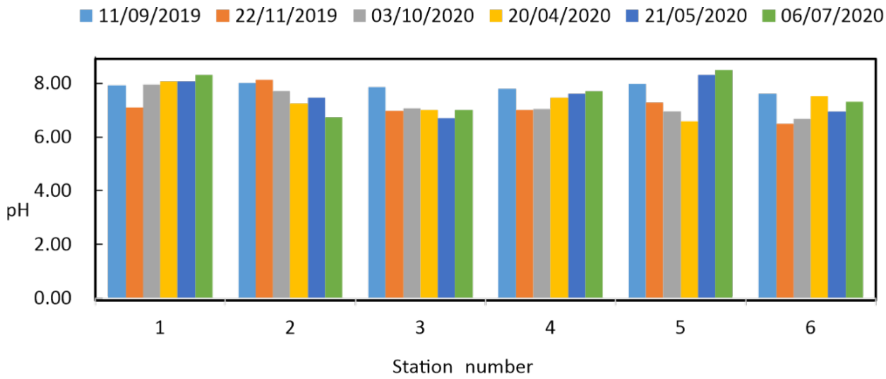

Fig. 7. Mean pH at six stations within 6 periods of time

In summer and spring, due to the high water hardness, the pH values were higher than in winter and autumn (Fig. 7). These findings show that the aquatic ecosystem of the studied area is not endangered (pH values ranging between 6.5 and 8.5, Table 2). The pH values obtained from the stations correspond to the correlation matrix and they have a positive relationship with EC and a negative relationship with temperature and ammonium (Table 5).

4.4. TURBIDITY

The average values of the turbidity at the sampling stations were between 1.88 and 10.05 NTU (Table 3). The location of the sampling station has a significant effect on turbidity. While the turbidities were low at the first sampling station in the basin of the Ghadruni Dam, it was higher at station 2 and station 6 and at the junctions of the two rivers near the reservoir and the dam (Fig. 8). Turbidity increases during the rainy months of the year. Also, lower turbidity has been observed where the speed of two currents decreases [21] due to spring and autumn rains and torrential summer rainfalls. In the study conducted by Pejman et al. [22], turbidity changes are almost equal in all seasons of the year. The turbidity is higher in summer and spring than that in autumn and winter. The changes correspond to weather conditions and seasonal changes. According to the correlation table, turbidity is not related to any parameter (Table 5).

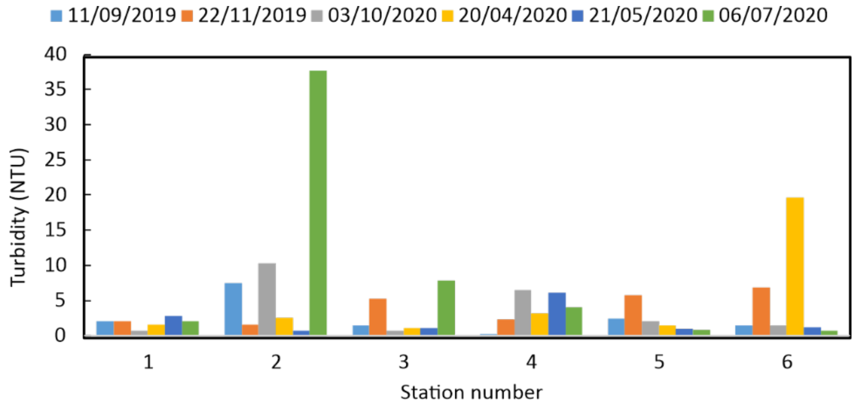

Fig. 8. Mean turbidity measured at six stations within 6 periods of time

4.5. SULFATES

The average range of sulfate concentration observed at sampling stations is between 291.166 mg/dm^3 and 128.83 mg/dm^3 (Table 3). The highest amount of sulfate was found at station 6 and was 870 mg/dm^3 (Table 2). At sampling stations 4 and 6, the two main streams of the Ghadrun and Hotkan Rivers connect, enter the dam reservoir, and are affected by all the wastewater of the route, the sulfate concentration is higher than at the other stations (Table 2). The level of sulfates is highest at stations 3 and 6 during the spring season (Fig. 9). However, the level of sulfates of spring waters combined with the stream is not ineffective. The observed sulfate levels increase with increasing sediments in the station 6 reservoir (Fig. 9).

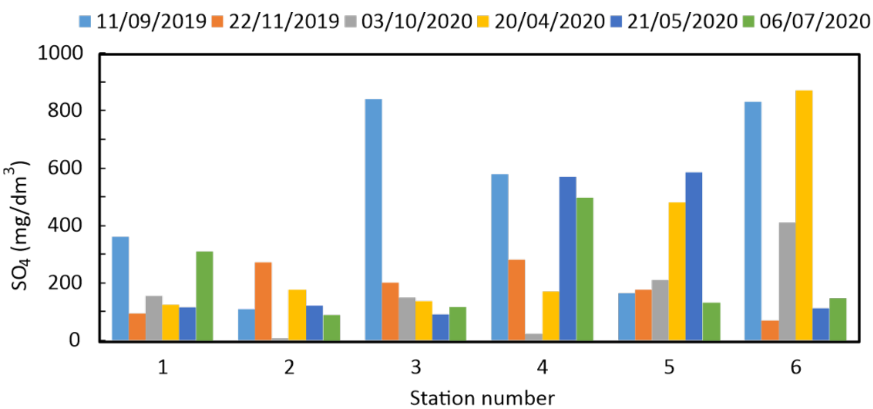

Fig. 9. Mean SO_4^{2-} concentrations at six stations within 6 periods of time

The sulfate parameter has a negative relationship and a strong inverse correlation with ammonium (Fig. 10).

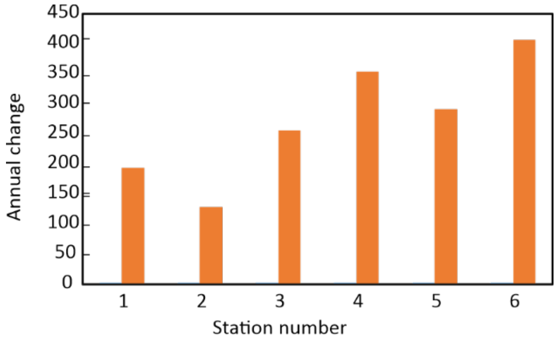

Fig. 10. Mean annual changes of SO_4^{2-}

4.6. NITRATES

The average amount of nitrates at sampling stations was between 11 and 17.66 mg/dm^3 (Table 3). Nitrate levels in various water samples differ significantly (Table 3). Relatively low concentrations were observed at the first and second stations away from the reservoir, which indicates that the amount of nitrate in the river inlets is higher due to industrial and domestic wastewater. Needless to say, high levels of nitrate have a significant effect on water quality.

The transfer of natural water and its combination with domestic and industrial wastewater and animal and mineral fertilizers used in the basin leads to an increase in the nitrate level of moisture. As a result, oxygen in the water decreases, and dissolved oxygen (DO) is reduced (station 5). Therefore, there is a negative relationship and an inverse correlation between the concentration of dissolved oxygen (DO) and nitrates (Table 5) .

The average amount of nitrates increases in spring and decreases in autumn. Usually, nitrate concentration increases from autumn to spring (Fig. 11). A high amount of nitrate in flood seasons, i.e., spring and summer, can be due to washing the basin and riverbed and wastewater. There is a positive and robust correlation between nitrate and COD, but a negative relationship and a healthy and inverse correlation with DO and ammonium (Table 5).

According to Chapman et al. [23], increasing concentration of nitrates is due to the effect of fertilizers used in the spring months. Higher concentrations of nitrates can be due to increased amounts of domestic, industrial, and agricultural wastewater caused by agricultural fertilizers in the study area. Boran and Sivri [24] found that the average concentration of nitrates increases during the spring months. In our study area, the average amount of nitrates fluctuates from 29 in spring to ca. 3.7 mg/dm^3 in autumn. This difference can be due to nitrate loading in winter and spring (Fig. 11).

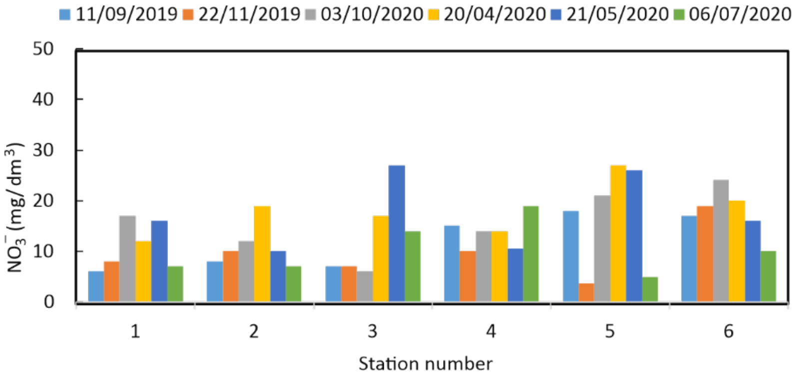

Fig. 11. Mean concentrations of NO_3^- measured at six stations within 6 periods of time

According to the correlation matrix, the concentration of nitrates directly relates to temperature, turbidity, TDS, nitrite, sulfate, and chloride; and is inversely related to ammonium and dissolved oxygen (Table 5).

4.7. NITRITES

The average amount of nitrites was between 0.025 mg/dm^3 and 0.63 mg/dm^3 at the sampling stations (Table 3). There are significant differences between the stations. The lowest nitrite content was found at station 3. Generally, at stations where there is domestic and industrial wastewater at the inlets, the amount of nitrite is higher than at the dam outlets (Table 2).

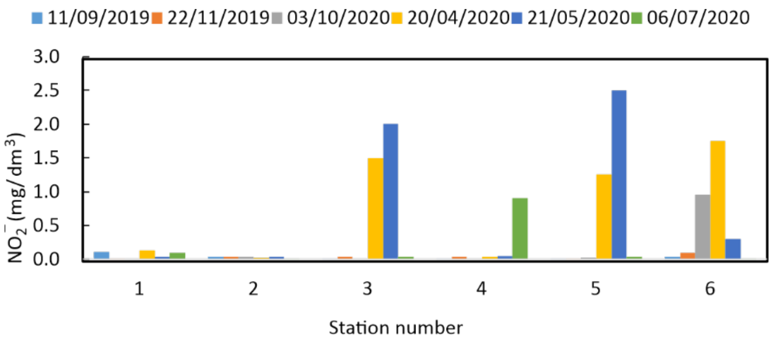

Fig. 12. Mean NO_2^- concentrations measured at six stations within 6 periods of time

Nitrites are a byproduct of the oxidation reactions of oxygen with the environment [26]. According to Chapman et al. [23], a high concentration of nitrite has a negative microbiologic effect on water and is considered industrial pollution. Ozdemir et al. [25] found that nitrite comes mostly from wastewater. In the study of the Ghadruni Dam, nitrite levels increase from autumn to spring (Fig. 12). The highest concentration of nitrites equal to 2.5 mg/dm^3 was found at station 5 (Fig. 12). Nitrites have no relationship with any parameter (Table 5).

4.8. CHLORIDES

During the laboratory observations, the average amount of chlorides obtained from the fifth sampling station ranged from 60.083 to 158.58 mg/dm^3, which is significantly different from the other stations (Table 3). The concentration of chlorides is higher at stations 6 and 3 – ca. 455 mg/dm^3 (Table 2).

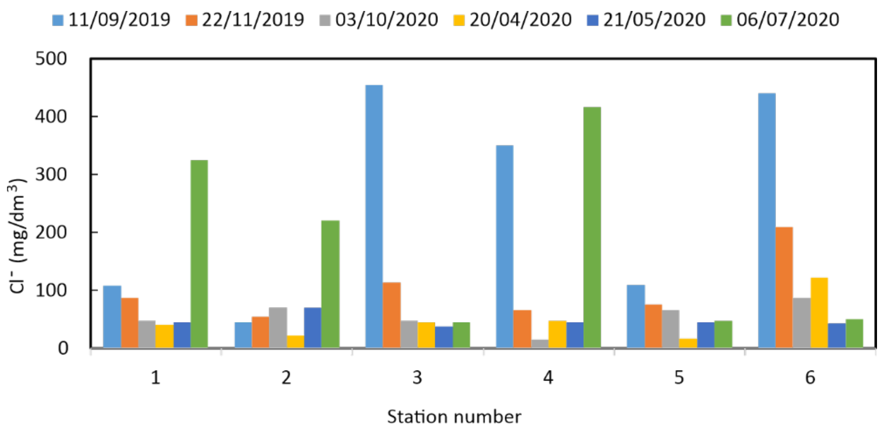

Fig. 13. Mean Cl^- concentrations measured at six stations within 6 periods of time

Leaving natural water and discharging wastewater in different seasons affects the amount of chloride in the water [27]. The chloride level increases in the autumn season due to the presence of agricultural wastewater (Fig. 13). Chloride has a positive and direct correlation with EC and TDS (Table 5).

4.9. TEMPERATURE

The average water temperatures recorded in this study were between 16.8 and 18.66 °C at the sampling stations (Table 3). The water temperature was almost the same in all the sampling stations (Fig. 14). According to the correlation matrix, temperature has a positive relationship with nitrogen, a strong correlation with dissolved solids, and an inverse relationship with pH (Table 5).

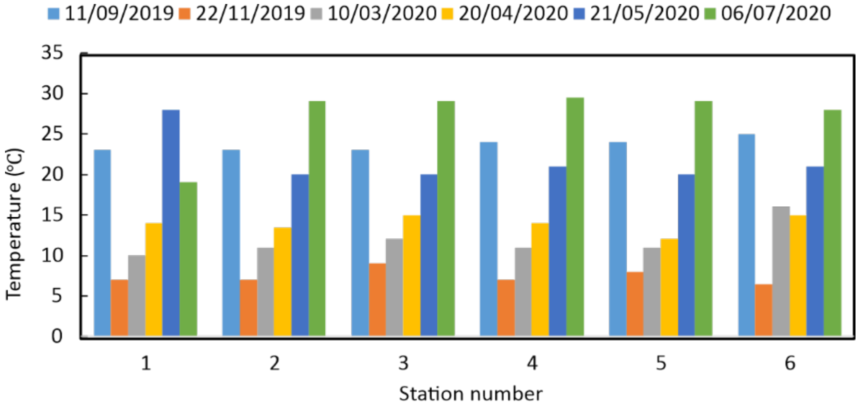

Fig. 14. Mean temperature measured at six stations within 6 periods of time

4.10. CHEMICAL OXYGEN DEMAND

With regard to the average values of COD, the highest amount of COD was 987 mg/dm^3 at the station 5, and the lowest amount of it was 51 mg/dm^3 at station 3 (Table 2). COD levels are higher in areas where domestic wastewater is being discharged. The lowest level of COD was determined in winter, while its highest level was in summer (Fig. 15). The reason for this increase in the ratio of organic matter can be investigated as it leads to an increase in microbial activities in the summer.

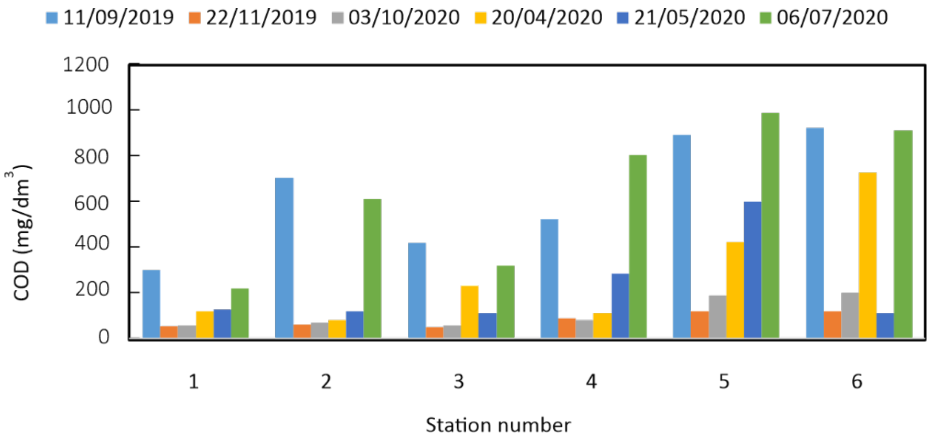

Fig. 15. Mean COD measured at six stations within 6 periods of time

Therefore, when the amount of COD increases, dissolved oxygen decreases. According to the correlation matrix, DO has a negative relationship and inverse correlation with ammonium and COD, respectively (Table 5). Also, COD values have a positive relationship with nitrates (Table 5).

4.11. AMMONIUM IONS

The lowest level of ammonium ions was 0.9 mg/dm^3, at station 2, whereas its highest level was 3.5 mg/dm^3 at station 5 (Table 2, Fig. 16). The tests of water samples show that the average value at the sampling stations was between 2.12 and 2.30 mg/dm^3 (Table 3). Seasonal investigations showed that ammonium levels were low in winter and high in spring (Table 4). Therefore, in the studied area, the concentration of ammonium was not very high, and this amount was due to the combination of organic fertilizers with water.

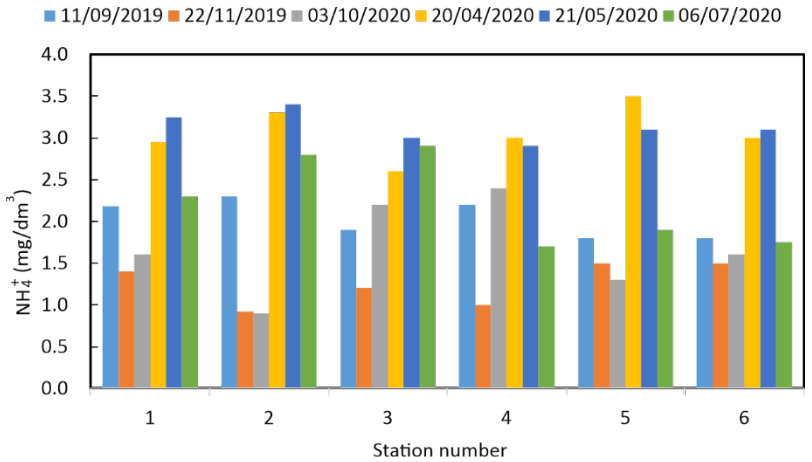

Fig. 16. Mean NH_4^+ concentrations measured at six stations within 6 periods of time

Olgun and Kocaemre [28] found that in Lake Mogan and the streams leading to it, the highest concentration of ammonium in spring was due to industrial and domestic wastewater, and chemical and agricultural fertilizers.

According to the conducted study, ammonium has a negative relationship and an inverse correlation with nitrate, sulfate, and COD concentrations. It also has a positive relationship and a strong correlation with DO (Table 5).

4.12. TOTAL NITROGEN

The average amount of total nitrogen at the sampling stations was almost between 176.666 mg/dm^3 and 234.166 mg/dm^3 (Table 3). The stations that are exposed to wastewater represent higher TN values (Table 2). Nitrogen levels decrease in winter and increase in spring (Fig. 17).

Katip and Karaer [29] discovered the highest level of nitrogen in spring. During the spring months, nitrogen reaches the highest level, which can be due to increased biological activities. Moreover, its decrease in autumn and winter is because of the reduction of the temperature of small creatures in the lake [30].

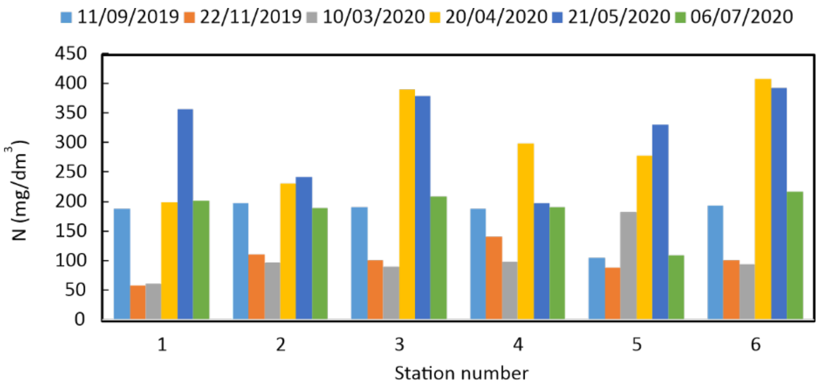

Fig. 17. Mean total N measured at six stations within 6 periods of time

After complying with Iranian water quality regulations (Table 6), it was found that the amount of nitrogen in the Ghadruni Dam is in an acceptable range. Nitrogen concentrations were between 57 mg/dm^3 in autumn and 408 mg/dm^3 in spring. Charkhabi and Sakizadeh [27] found that nitrogen compounds are responsible for the foul smell felt in the region. In the basin of the Ghadruni Dam, as we go from winter to spring, we inhale a lousy odor of nitrogen compounds that have penetrated the reservoir. The sedimentation of nitrogen compounds is also significant in this regard. Nitrogen level has a direct relationship with temperature and a negative and inverse relationship with pH (Table 5).

4.13. DISSOLVED OXYGEN

The average concentrations of dissolved oxygen at the stations were between 3.33 and 5.51 mg/dm^3 (Table 3). The highest and the lowest values, 10.48 and 1.1 mg/dm^3 were recorded at station 3 (Table 2). On the junction of the two main streams of the Ghadrun and Hotkan Rivers, the flow accelerated, DO level increased, and reached 7 mg/dm^3.

At stations 5 and 6, the oxygen concentrations are almost equal. At stations with slightly higher wastewater flow, the value of DO decreased, and at stations away from the reservoir, it increased in some parts of surface waters. The average concentration of DO depends on such factors as temperature, salinity, and air pressure [31]. Lower temperatures increase the solubility of oxygen and DO increases [32]. However, with increasing temperature, the dissolution of oxygen decreases, and the DO reaches its lowest level in summer (Fig. 18).

Charkhabi and Sakizadeh [27] concluded that DO levels in winter and autumn are higher than that at spring and summer. According to the correlation matrix, DO has a direct relationship with ammonium, and a negative relationship and an inverse correlation with nitrate and COD (Table 5).

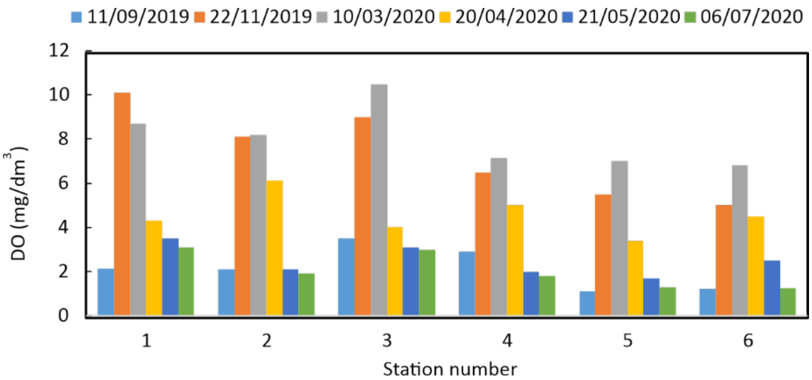

Fig. 18. Mean DO measured at six stations within 6 periods of time

5. CONCLUSION

The water quality of seasonal rivers was investigated. The characteristics of permanent rivers in terms of useful quality parameters and their effects were studied. Also, the water pollution of the Ghadruni Dam, which is the result of the two main streams leading to this dam, was qualitatively studied and evaluated and compared with the regulations and permissible limits of Iranian waters. The causes of pollution and the parameters affecting water quality were determined. Getting information on the water quality of seasonal rivers can help us make reasonable decisions. Due to floods and the transfer of pollution in the basin to the river, changes in quality parameters during rainy and drought months are predictable.

The obtained results showed that the released wastewater is one of the significant sources of pollution in the basin. All changes at the sampling stations and all parameters were examined seasonally throughout the year, and their different values were obtained.

Water consumption from the dam for agricultural and industrial purposes meets the standards. However, in some cases, it was contaminated and did not comply with the standard criteria for drinking water. Nevertheless, since the main purpose of constructing the dam was to provide drinking water, this objective can be achieved by controlling the quality parameters and taking precautions.

Pollution in the basin area, due to environmental degradation, and pollution of the basin itself, due to human, animal, and waste activities increase the biological contamination of river water during the rainy seasons compared to the warmer months.

Increasing the load of pollution of inlet flows to the reservoir of the Ghadruni Dam, as an essential source of drinking water supply for two cities, industry, and agriculture of the region, is associated with the risk of decreased quality of the dam's outlet water.

Parameters such as electrical conductivity, turbidity, COD, TDS, nitrite, nitrate, sulfate, and chloride concentrations at polluted stations have shown increasing values, while dissolved oxygen (DO) has decreased. The quality ranks and effectiveness of each parameter were analyzed. The relationship between different parameters was obtained. It was found that EC has a positive relationship with TDS and chloride and TDS has a positive and direct relationship with EC, chloride concentration, and temperature, and DO has a positive relationship with ammonium ions and an inverse relationship with nitrates and COD. The temperature also has a positive relationship with nitrogen and dissolved solids but a negative relationship with pH.

Ghadruni Dam is affected by agricultural pollution from different sources and from two main streams of the Ghadrun and Hotkan rivers, which are the main feeders of this dam. The problem of pollution can result from agricultural activities and industrialization of the region. Indeed, soon, there is a need to drain the sludge on the bottom of the dam, which can be one of the ways of reducing pollution. In this way, we can reduce pollution. However, if we do not deal with the discharge of wastewater and the uncontrolled growth of agricultural fertilizers in the region, we cannot eliminate the pollution. Today, environmentalists have found many solutions to the problem of wastewater. However, due to the management problems and the low efficiency of this dam, it was not possible to eliminate the pollution entering this dam seriously. We concluded that one of the most important causes of pollution in this region was man-made pollution controlled and eliminated. We should solve management problems and have short-term and long-term planning to solve them. These sources of pollution, which are mostly agricultural fertilizers used in the region and domestic and industrial discharges, should be reduced by environmental regulations. Since this dam provides a large volume of drinking water to the area and agriculture, this problem should be solved as soon as possible. However, because the feeding rivers of this dam are seasonal, unfortunately, the ecological shape of these lakes shows itself more, which can be a severe threat to the region. Therefore, considering that there may be a severe threat to the future of the dam lake, which can cause destructive environmental effects on the region, protecting the environment and controlling the pollution of its streams should be seriously considered by all the respected organizations.

This reservoir provides desirable artificial moisture to protect the environment and creates an artificial wetland for the survival of birds. Some rare birds are observed in this wetland. The reduction of migratory birds and numerous droughts in this area, as well as increasing temperature, decreasing groundwater, and decreased humidity, have created many ecological problems for the region. With the construction of this dam and a lake reservoir, we can overcome the mentioned problems.

On the other hand, agricultural pollution and some industrial and domestic wastewater in this basin caused newer problems in the region. One of the issues of this region is the lousy smell felt during the warm seasons of the year. It is essential to prevent the mentioned pollution in the dam. It is efficient in producing healthy agricultural products and providing safe drinking water for the residents of these two cities. The situation of waste collection in the rural area is still one of the significant health problems in this region. Soil degradation due to artificial degradation, land-use change, and vegetation degradation are the causes of soil erosion during rainfall and the transfer of soil contaminants to the river.

By releasing some water upstream, it may be possible to prevent the effects of spring sulfurous waters and sulfate and nitrate compounds that reach the reservoir of the dam from agricultural fertilizers. One of the most critical problematic factors in the future can be population growth in the region, which needs serious attention. Studies related to soil protection should also be seriously pursued and each organization should present its studies to the management of the dam, and public participation should also be taken into consideration. All executive organizations should collaborate in this regard. Also, all beneficiaries and residents living in the neighborhood of this basin should participate in sustainable water management and improving water quality. The integrated water management plan of the Ghadruni Dam basin should be considered by everyone. All beneficiaries should collaborate in developing a comprehensive plan for the sustainable management of healthy water resources.

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