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Original Article

Determination of the amount of Sanitary Water Flow from Dams based on the Quality of Drinking Water: A Case Study, Taleghan River, Iran

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Abstract

Background: Given the crisis of water shortage and the industrial development in Iran, comprehensive water-resource management and planning to handle the water quality of the rivers are the critical issues to tackle with. The concentration of river pollutants is a function of both the quantity and quality of the river flow regime. In this regard, the construction of large dams leads to quantitative and qualitative changes in downstream rivers. These changes are effective in the health of the river water for uses such as drinking, agriculture, and industry. Therefore, in addition to the quantity of water needs of rivers, their quality needs to be also considered.

Objectives: This study aimed to analyze issues related to the sanitary water flow of large dams. Our case study was the Taleghan River dam, Alborz Province, Iran, on which Taleghan reservoir was built to supply some part of the water needed by Greater Tehran, Iran.

Methods: This study examined a 22-km long section of the river at the riffle of Taleghan Dam in Alborz Province (103 km from Karaj), Iran. The average annual and monthly discharges of the river in four 6-km-apart stations were estimated. The statistics of eight hydrometric stations and a discharge-surface method were used to calculate the average annual discharge of each sub-basin downstream of Taleghan Dam. Moreover, the discharge non-dimensionalization method, along with the observational statistics of the index station, was used to calculate the average monthly discharge in the examined stations. The Hydrologic Engineering Centers River Analysis System (HEC-RAS) software (version 4.0) was then utilized to determine the values of river flow rates hydraulically. Additionally, water quality parameters were compared with the standard concentrations proposed by the World Health Organization (WHO) for drinking-water quality to examine possible changes in pollutant concentrations during the study. Correlation and regression statistical tests in SPSS software (version 24) were then used to analyze the relationship between discharge and pollutant concentration.

Results: The experimental equation of $Q = 0.0372A^{0.8641}$ was obtained to estimate the discharge based on the sub-basins area using the discharge-surface method. The average annual discharge at stations 2, 3, and 4 (B, C, and D) were estimated at 1.39, 2.11, and 3.39 m^3/s, respectively, using this equation. Subsequently, the average monthly discharges in the studied stations in September were calculated at 0.21, 0.29, and 0.46 m^3/s, respectively. Afterward, the discharge was measured using HEC-RAS software (version 4.0) in the same month at 0.34, 0.44, 0, and 0.62 m^3/s, respectively. The examination of water quality values from among the 17 water quality parameters revealed that physicochemical elements, pH concentration, lead (Pb), and electrical conductivity were higher than the standard concentration of drinking water proposed by the WHO.

Conclusion: A model was presented to estimate sanitary water flow by performing correlation tests and linear regression calculations between the river discharge at the dam downstream and the concentration of water quality parameters. According to the proposed model, the minimum flow of sanitary water was estimated at 1.82 m^3/s to be considered to release from the dam in the driest month of the year. Therefore, the release of water as the minimum flow of sanitary water less than 1.82 m^3/s was not allowed in any other month of the year.

Keywords: Sanitary water, Taleghan River, Water pollution, Water quality downstream of large dams

1. Background

In the past decades, the tremendous increase in freshwater demand in the world has led to industrial development and gradual population growth (1). In this regard, given the crisis of water shortage and industrial development in Iran, some of the most vital issues that need to be considered are comprehensive management of water resources and planning of water quality of rivers (2). Comprehensive water-resource management is a process to promote the coordination required between the development and management of water, soil, and other related resources to increase welfare and economic and social justice by considering the sustainability of the critical ecosystems. The most significant approach for the sustainability of watershed services and ecosystems is creating and maintaining a flow system and natural river flow (3). Natural treatment powers the rivers, based on their hydrological, hydraulic, and biological factors and conditions and enables them to absorb pollutants from the river environment (4) as the preservation of the river ecosystem relies on river quantity and quality of flow-regime. Moreover, the construction of huge dams leads to both quantitative and qualitative changes in downstream rivers, which affects river-water sanitary use. Therefore, it is essential to consider both the quality of river water and the quantity of river water demands (5).

The data that describe temporal and spatial changes of water quality in a river can be utilized to introduce the relative significance of human and natural impacts. The most important steps of water quality evaluation are classification, simulation, and interpretation of monitoring data. Water quality evaluation can be based on a statistical analysis of the collected physical, chemical, and biological data (6). Several studies have been conducted investigating the quantity and quality of rivers. Ban et al. studied the effect of the dam of three valleys in China on the downstream regime through systematic examinations of different hydrological indices before and after the dam (7). Esmaili et al. examined 13 physicochemical parameters and heavy elements of water in 4 points of the Danube River, Europe. The findings of the mentioned study indicated that the water quality of the river was normal, based on the Canadian Council of Ministers of the Environment Water Quality Index (8).

Christopher et al. examined the water quality of the Oji River in Nigeria. The findings revealed that the concentration of turbidity, total dissolved solids (TDS), electrical conductivity (EC), and coliform in the river in dry and wet seasons exceeded those recommended by the Food and Agriculture Organization and WHO standards (9). Chadrik examined water physicochemical parameters from four sampling stations in the Yamano River, India. The findings indicated that according to the river drinking water standard proposed by WHO, it was not possible to use it for domestic purposes (10). Sanyal et al. examined the role of dam construction on the morphology of the Theost River downstream of the dam in India. The result showed a reduction in the quantity and quality of river water (11). Junguo et al. examined the water quality of the Huang River Basin in Mongolia, China. The results showed that 26% of the total water resources needed to be allocated to dilute the concentration of pollutants and maintain the sanitary consumption of the river (12). In another study, Tokatli studied the physicochemical parameters of Arjan River water in Trachea Region using statistical techniques and regression relationships. The findings indicated that the Arjan River was exposed to a significant amount of pollution (13). Tajmunnaher et al. examined the water quality parameter in the Kushiyara River in Bangladesh. The results showed that the physicochemical parameters of water in rainy and dry seasons were more than the standard concentration of water suggested by WHO, and it was necessary to reduce water withdrawal from the basin to maintain the balance of the water quality (14).

In another study, Dey et al. investigated the water quality of the Karnafuli River in Chittagong, Bangladesh. The results showed that the physicochemical parameters were significantly higher than the recommendations by the WHO for drinking water and the river was highly polluted in terms of chemical contaminants and pathogenic bacteria (15). In another study, Taheri Hedayatzadeh et al. examined the physicochemical quality of Cesar River in Iran water using multivariate statistical techniques. The findings indicated that the concentrations were above the standard of drinking water recommended by the WHO (16). Furthermore, Parandak et al. examined the simulation and water quality of the Karaj River, Iran, using a river and stream water quality model (i.e., QUAL2K) The findings indicated that the main pollution of the Karaj River downstream of the Amir Kabir Dam in Karaj was related to urban wastewater (17).

In another study, Arabs and Kherad Naruyi examined the water quality of the Golrudbar River in Semnan. Accordingly, the water of the Golrudbar River was not suitable for drinking water and agriculture purposes (18). Moreover, Mahmoudian et al. investigated the physicochemical quality of Zohreh River water, Iran, based on the Iranian National Standard (Code of 1053) of drinking water. Based on the obtained findings, Zohreh River water was unsuitable for drinking without treatment (19).

Since maintaining the sanitary consumption of the river for various uses depends on the quantity and quality of the river flow regime, it is essential to study the quantity and quality of rivers affected by different pollutants discharged in it.

2. Objectives

This study aimed to analyze issues related to the sanitary water flow of large dams. Our case study was the Taleghan River dam, Alborz Province, Iran, on which Taleghan reservoir was built to supply some part of the water needed by Greater Tehran, Iran.

3. Methods

In this descriptive-inferential study, descriptive statistics, information, and field measurements were applied to identify the factors affecting water quality to provide sanitary water flow in a selected 22-km-long section of Taleghan River downstream of Taleghan Dam. The study area was in Alborz Province in 103 km of Karaj, Iran. Taleghan River is one of the sub-tributaries of Sefid Roud, forming the Shahroud River by joining the Ghezel Ozan River in Manjil after joining the Alamut River (Figure 1).

A combined method based on hydrological and hydraulic approaches was employed to determine the desired base flow in the study. Accordingly, first, both the area (border) of Taleghan Dam watershed and the sub-basins leading to Taleghan River downstream of the dam were determined using a digital topographic map with a scale of 1:50,000 based on the water division line (ridges) and using the

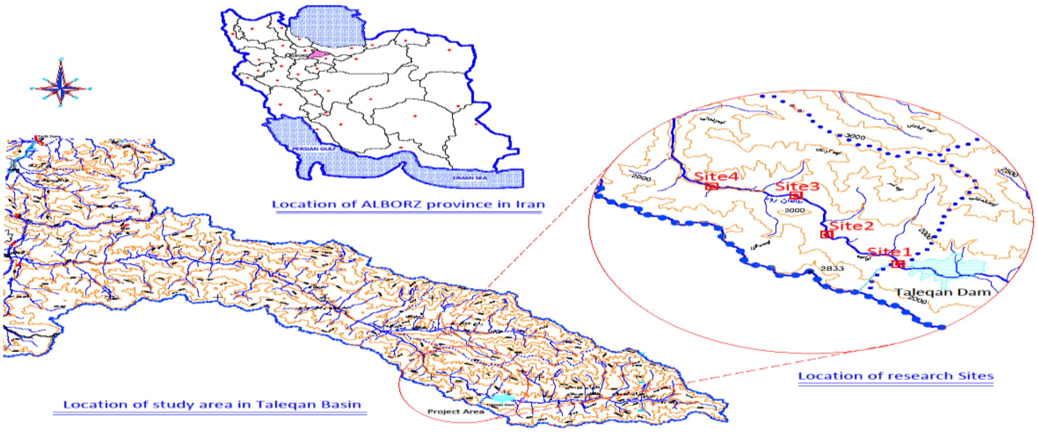

Figure 1. Location map of the study site

Geographic Information Systems (GIS) and ARC-GIS10 software package. Afterward, four study sites were selected from the below of the dam to the western border of the Kolahroud sub-river using topographic maps, Google Earth satellite imagery, and information from the region in the GIS environment. These sites were at distances of 250 m, 9 km, 15 km, and 22 km from the body of Taleghan Dam. River water samples were collected during the study period to examine the river water quality downstream of Taleghan Dam.

The statistics of eight hydrometric stations (Table 1) were used to estimate the average annual discharge of each sub-basin downstream of Taleghan Dam. The discharge of sub-basins at the study stations at their exit point was examined employing the discharge-surface method with the highest correlation coefficient and establishing linear regression relationships using the monthly discharge statistics of the mentioned hydrometric stations located upstream and downstream of Taleghan Dam. Discharge non-dimensionalization was performed using observational statistics of Glinak hydrometric station, Taleghan, Iran, which is one of the key hydrometric stations with long-term statistics (from 1959 to 2014) and a complete statistical time series in the region. This station was used as the index station to calculate the average monthly discharge in the examined stations.

The prepared samples of river water in each laboratory of Sheikh Baha'i laboratory complex of Tehran Science and Research Branch, Islamic Azad University, Tehran, Iran. The tests were performed based on the American Public Health Association standard method of water analysis (1992) using standard analyzers, such as the digital thermometer, oxygen meter, and PH meter WTW (model 340i), AHCH model spectrometry, Aqualytic turbidity meter, and three-tube most probable number method to evaluate the quality of river water samples during the examined period. Given the explanations provided, the water quality parameter, including physicochemical pollutants, and heavy and biological elements were examined using samples collected from river water in the four selected stations. Moreover, each of the water quality parameters with the standard concentrations of WHO drinking water quality parameters was used to compare possible changes in the concentration of pollutants in the studied period. It was observed that from among the 17 water quality parameters, the concentration of physicochemical elements and lead (Pb), PH, and EC were higher than the standard concentration.

Table 1. Names and specifications of the examined hydrometric stations

Station	Area (km^2)	Medium discharge (m^3/s)
Dehdar - Dehdar	41	0.85
Taleghan Jostan - Shahroud	428	8.39
Alizan Jostan - Shahroud	64	1.72
Gateh Deh - Gateh Deh	84	1.32
Glinak (Shahroud) - Shahroud	848	12.69
Baghkalayeh - Shahroud	695	8.78
Khuban - Alamut	245	4.72
Rafi Khoshkdast - Shahroud	56	1.22

4. Results

Discharge estimation in each station was calculated by creating regression relationships and using the equation of $Q = 0.0372A^{0.8641}$; accordingly, the average annual discharge rates at stations 2, 3, and 4 (B, C, and D, respectively) were obtained at 1.39, 2.11, and 3.39 (m^3/s), respectively. Furthermore, the results obtained from the estimation of the monthly baseline discharge (Table 2) in each of the stations were calculated at a confidence level (CI) of 95% (P=0.05). This estimation was fulfilled using long-term statistics measured and recorded in Glinak hydrometric station (from the water years of 1959-1960 to 2016-2017) in the Taleghan River watershed based on possible monthly discharge values.

A decrease in the flow (discharge) rate led to

Table 2. Average monthly base discharge in the examined stations (m^3/s)

Month Station	October	November	December	January	February	March	April	May	June	July	August	September	Annual average
(B) 2	0.26	0.35	0.17	0.24	0.31	0.56	1.34	1.67	1.34	0.50	0.29	0.21	0.60
(C) 3	0.46	0.52	0.31	0.37	0.47	0.85	2.04	2.53	1.47	0.64	0.37	0.29	0.86
(D) 4	0.64	0.84	0.51	0.60	0.75	1.37	3.27	4.05	2.36	1.03	0.60	0..46	1.37

Table 3. Measurement of hydraulic parameters of the Taleghan River in the examined stations (June 2017)

Stations	High width (m)	Bed slope (Percentage)	Flow cross-section (m^2)	Flow rate (m/s)	Discharge (m^3/s)
2	3.86	0.022785	0.57	1.03	0.34
3	6.55	0.020827	0.58	0.77	0.44
4	9.39	0.009989	0.77	0.80	0.62

Table 4. Measurement of hydraulic parameters of the Taleghan River in the examined stations (September 2017)

Stations	High width (m)	Bed slope (Percentage)	Flow cross-section(m^2)	Flow rate (m/s)	Discharge (m^3/s)
2	3.34	0.023169	0.33	0.99	0.33
3	6.36	0.022815	0.53	0.79	0.41
4	9.10	0.010003	0.73	0.77	0.58

changes in flow cross-section, depth, and even flow velocity (as the hydraulic parameters of the river). As a result, the quality of the river flow changed correspondingly. Since there is a relationship between river hydraulic parameters, including wet environment, depth, and flow rate (20), one can calculate the flow needed for optimal conditions using such a relationship. To this end, HEC-RAS software (version 4.0) based on mapped and measured field data was used to study and analyze the hydraulic properties of Taleghan River in the examined scale (22 km long) at the stations downstream of Taleghan Dam. Subsequently, the flow rates of the river were estimated hydraulically as a discharge and compared with the discharge (Table 2) to measure the adequacy of river flow to supply the sanitary water (tables 3 and 4).

The results of a study conducted by Hadipour Niktarash et al. about pH values in low-water and high-water seasons indicated that the water of Taleghan River was more alkaline in high-water seasons than in low-water seasons (21). This means that the decrease in the water would lead to an increase in the acidity (pH) of the Taleghan River, which was in line with the results of the present study. Consequently, the results of analyzing 17 water quality parameters measured and recorded downstream of the dam showed that EC, pH, and Pb concentration were far more than the standard level, compared to the standard concentration recommended by WHO drinking water (tables 5-9).

The results of the Pearson correlation analysis between water quality parameters (i.e., pH, Pb, and EC) with river discharge (i.e., Q) in the studied

Table 5. Comparison of the concentration of measured parameters in Station 1 with the standard concentration of drinking water

Row	Sampling station	Discharge (m^3/s)	Parameter	Parameter concentration (mg/l)	Standard concentration of drinking water (mg/l)	Status
1	1	0.12	Mg	11.89	Less than 15.0	Suitable
2			pH	8.11	5-8	Unsuitable
3			TH	219.00	500	Suitable
4			EC	371.00	250	Unsuitable
5			TDS	198.00	1,000	Suitable
6			Cl	0.006	0.5	Suitable
7			NO_2	0.024	0.2	Suitable
8			NO_3	1.70	50-100	Suitable
9			SO_4	67.00	400	Suitable
10			Na	31.20	Less than 75	Suitable
11			K	1.67	12	Suitable
12			Fe	0.01	1	Suitable
13			Ca	56.80	200	Suitable
14			Pb	0.21	0.1	Unsuitable
15			Ni	0.018	Less than 0.10	Suitable
16			Mn	0.037	0.5	Suitable
17			As	0.00	0.5	Suitable

EC: Electrical conductivity; TDS: Total dissolved solids; TH: Total water hardness

Table 6. Comparison of the concentration of the parameters measured in Station 2 with the standard concentration of drinking water

Row	Sampling station	Discharge (m^3/s)	Parameter	Parameter concentration (mg/l)	Standard concentration of drinking water (mg/l)	Status
1	2	0.42	Mg	11.280	Less than 15.0	Suitable
2			pH	8.410	5-8	Unsuitable
3			TH	102.150	500	Suitable
4			EC	317.000	250	Unsuitable
5			TDS	209.000	1,000	Suitable
6			Cl	0.0052	0.5	Suitable
7			NO_2	0.019	0.2	Suitable
8			NO_3	0.023	50-100	Suitable
9			SO_4	66.80	400	Suitable
10			Na	69.100	Less than 75	Suitable
11			K	3.170	12	Suitable
12			Fe	0.050	1	Suitable
13			Ca	78.400	200	Suitable
14			Pb	0.530	0.1	Unsuitable
15			Ni	0.020	Less than 0.10	Suitable
16			Mn	0.013	0.5	Suitable
17			As	0.012	0.5	Suitable

EC: Electrical conductivity; TDS: Total dissolved solids; TH: Total water hardness

Table 7. Comparison of the concentration of the parameters measured in Station 3 with the standard concentration of drinking water

Row	Sampling station	Discharge (m^3/s)	Parameter	Parameter concentration (mg/l)	Standard concentration of drinking water (mg/l)	Status
1	3	0.63	Mg	9.160	Less than 15.0	Suitable
2			pH	8.640	5-8	Unsuitable
3			TH	122.000	500	Suitable
4			EC	307.000	250	Unsuitable
5			TDS	215.000	1,000	Suitable
6			Cl	0.0042	0.5	Suitable
7			NO_2	0.010	0.2	Suitable
8			NO_3	1.600	50-100	Suitable
9			SO_4	65.60	400	Suitable
10			Na	31.150	Less than 75	Suitable
11			K	1.620	12	Suitable
12			Fe	0.010	1	Suitable
13			Ca	49.700	200	Suitable
14			Pb	0.57	0.1	Unsuitable
15			Ni	0.018	Less than 0.10	Suitable
16			Mn	0.001	0.5	Suitable
17			As	0.000	0.5	Suitable

EC: Electrical conductivity; TDS: Total dissolved solids; TH: Total water hardness

Table 8. Comparison of the concentration of the parameters measured in Station 4 with the standard concentration of drinking water

Row	Sampling station	Discharge (m^3/s)	Parameter	Parameter concentration (mg/l)	Standard concentration of drinking water (mg/l)	Status
1	4	1.02	Mg	8.670	Less than 15.0	Suitable
2			pH	8.420	5-8	Unsuitable
3			TH	162.00	500	Suitable
4			EC	309.00	250	Unsuitable
5			TDS	229.00	1,000	Suitable
6			Cl	0.0040	0.5	Suitable
7			$_2NO$	0.021	0.2	Suitable
8			$_3NO$	0.500	50-100	Suitable
9			$_4SO$	64.81	400	Suitable
10			Na	31.110	Less than 75	Suitable
11			K	1.640	12	Suitable
12			Fe	0.010	1	Suitable
13			Ca	52.500	200	Suitable
14			Pb	0.220	0.1	Unsuitable
15			Ni	0.024	Less than 0.10	Suitable
16			Mn	0.005	0.5	Suitable
17			As	0.000	0.5	Suitable

EC: Electrical conductivity; TDS: Total dissolved solids; TH: Total water hardness

stations (Table 10) indicated a significant correlation (0.903) between discharge and acidity (pH) at the 98% CI (P=0.02). However, the correlation coefficients of discharge with Pb concentration and EC were obtained at -0.335 and 0.226, respectively, which were not statistically significant. Therefore,

Table 9. Comparison of the concentration of parameters with a concentration higher than the standard concentration of drinking water

Station	Discharge (m^3/s)	Parameters with concentrations above the standard	Parameter concentration (mg/l)	Standard concentration of drinking water (mg/l)	Difference with standard concentration (mg/l)
1	0.12	pH	8.110	5-8	0.11
		EC	317.000	250	67
		Pb	0.21	0.1	0.11
2	0.43	pH	8.410	8-5	0.410
		EC	317.000	250	67
		Pb	0.530	0.1	0.43
3	0.63	pH	8.640	8-5	0.64
		EC	307.000	8-5	57
		Pb	0.57	0.1	0.47
4	1.02	pH	8.420	8-5	0.42
		EC	309.00	250	59
		Pb	0.220	0.1	0.12

EC: Electrical conductivity; TDS: Total dissolved solids; TH: Total water hardness

Table 10. Correlation between river discharge and the parameters with concentrations higher than the standard of drinking water

		Discharge	pH	Pb	EC
Discharge	Pearson correlation	1	0.903**	-0.335	0.226
	Sig. (2-tailed)		0.002	0.418	0.590
	n	8	8	8	8
pH	Pearson correlation	0.903**	1	-0.500	0.507
	Sig. (2-tailed)	0.002		0.208	0.200
	n	8	8	8	8
Pb	Pearson correlation	-0.335	-0.500	1	0.006
	Sig. (2-tailed)	0.418	0.208		0.988
	n	8	8	8	8
EC	Pearson correlation	0.226	0.507	0.006	1
	Sig. (2-tailed)	0.590	0.200	0.988	
	n	8	8	8	8

**Correlation was significant at the 0.01 level (2-tailed).
EC: Electrical conductivity

given the correlation coefficients, pH was a more suitable index than Pb and EC. This finding was in line with and confirmed the result of changes in the water quality of the Taleghan River in the downstream dam.

Given the significant correlation between the pH values as predictors and the river discharge (i.e., Q) downstream of Taleghan Dam, the results of multiple regression analyses (i.e. Inter regression model) showed that There was a significant correlation between pH and river discharge (i.e. Q) in the downstream of Taleghan Dam (tables 11-13).

According to the results of the analysis of variance in Table 12, a significant relationship is observed between the minimum flow of sanitary water in the river and the acidity (pH) at the 98% CI (P=0.002).

Given the above and the findings in Table 13, the regression relationship (as a model for determining the minimum flow of sanitary water) is as follows:

$$Q_{min} = 1.327\text{pH} - 10.665$$

Table 11. Summary of coefficient of determination in the regression model

Model	R	R-squared	Adjusted R-squared	Std. error of the estimate	R-squared change	Sig. F change
1	0.903[a]	0.816	0.786	0.16214	0.816	0.02

a. Predictors: (Constant), pH

Table 12. Results of the variance analysis of the regression model

Model		Sum of squares	Mean square	F	Sig.
1	Regression	0.700	0.700	26.643	0.002[b]
	Residual	0.158	0.026	-	-
	Total	0.858	-	-	-

b. Predictors: (Constant), pH

Table 13. Regression model coefficients and their significance test

		Unstandardized coefficients		Standardized coefficients			95.0% Confidence interval for B	
Model		**B**	**Std. error**	**Beta**	**T**	**Sig.**	**Lower bound**	**Upper bound**
1	(Constant)	-10.665	2.173	-	-4.908	0.003	-15.982	-5.348
	pH	1.327	0.257	0.903	5.162	0.002	0.698	1.956

a. Dependent Variable: Q

where Q_{min} is the minimum sanitary water flow (m^3/s) and pH is the acidity in the river water.

5. Discussion

Considering the results of this study, it can be concluded that most of the studies performed in the field of river health status have dealt with the issue of river water quality parameters. Therefore, they can be used in targeted river monitoring programs as low-cost and targeted methods. One of the most widely used approaches in evaluating water quality is based on comparing the observed value of a variable in a water sample with its existing reference guide. However, to evaluate river water quality, numerous variables are required, which their tabulation and interpretation are sometimes difficult even for water experts (22). Moreover, this approach does not always provide a complete and integrated view of the water quality status. Consequently, several measures have been employed to deal with this problem, such as water quality indices (WQI) (23). Multivariate statistical analysis approaches have been demonstrated to be efficient in reducing the volume of data and can be used as suitable statistical techniques for quality monitoring and sustainable management of rivers in Iran. The same results have been reported by Tokatli, Ban et al., Parandak et al., Hedayatzadeh et al., Hadipour Niknejad et al., and Rostami Klor et al. (5, 13, 15, 16, 21, 24). According to the results from the analysis of the tested samples from 4 stations (tables 5-9), of the 15 measured parameters in the present study, pH, Pb, and EC exceeded the standard of drinking water recommended by the WHO. According to the observations and the analysis of samples, the water of the Taleghan River was unsuitable for drinking in a range of 22 km from the downstream of Taleghan Dam up to Kolahroud village in the downstream of the Taleghan Dam. Hadipour Niknejad et al. examined the chemical parameters of water upstream of this river (10) and obtained the range of changes in pH values at 8.2. In another study, Rostami Klor et al. (18) performed sampling in the main course of the river upstream of Taleghan Dam in 11 stations up to the dam entrance and reported the range of pH changes from 8.4 to 8.53. These values were consistent with those measured in the present study (tables 5-8). The difference between the changes in TDS concentration measured by Rostami Klor for the upstream of Taleghan Dam (24) and those in the present study calculated for the downstream of Taleghan Dam shows that the construction of the dam significantly reduces the mud (because of fine-grained sediments suspended in water). This reduction was attributed to the deposition of erosive materials (coarse and fine-grained sediments, even sediments suspended in water due to soil erosion in the dam watershed) in the reservoir. In this respect, it demonstrated the effect of dam construction on the quantity and quality of water in Taleghan in the period of examining the downstream of the dam.

According to Babran, the preservation of the river ecosystem relied on the quantity and quality of the river flow regime, and the construction of large dams caused quantitative and qualitative changes in the downstream rivers, which were effective in the sanitary consumption of river water (6). Therefore, in addition to the amount of the demands of surface water and groundwater, their quality should also be considered (25). Accordingly, it is essential to keep the reliable quantity and quality of the water required to maintain the ecological function on which humans depend. In this regard, meeting the hydro-ecological goals of the river need to be considered as well, in addition to water quality and quantity. Consequently, after measuring the physicochemical parameters of water, the quantitative parameters of the monthly and annual discharge of Taleghan River were calculated in the present study during the period of examining downstream of the dam. According to calculations and comparisons, the measured discharge of the Taleghan River in the study period (tables 3 and 4) was 0.58 m^3 in September (the driest month of the year), compared to the discharge of the river (Table 2) calculated at 0.46 m^3 in the same month. The river faced a 30% flow reduction during the examined period due to the lack of water release from the dam. This value needed to be added to the discharge of river flow downstream of Taleghan Dam to reduce the concentration of water acidity (pH), Pb, and EC up to the standard of drinking water recommended by the WHO. This is in line with the results of Janko et al. (13), who suggested a 26% increase in discharge of water resources to dilute and reduce pollutant concentrations.

Irreparable damage to the river ecosystem will be inevitable if the water entering the river has physicochemical pollutants more than the water released from the downstream of the dam and the water released is insufficient to dilute the pollutants. Therefore, this research was conducted to present a model to provide an approach to deal with the challenge concerning the sanitary flow of rivers downstream of dams in terms of drinking water quality. It is noteworthy that the results of this study were based on water quality data in the riffle of the Taleghan River dam downstream during the examined period. Regarding this, it is recommended to conduct similar studies to investigate the verification of this relationship and its possible completion in the riffle of the downstream of other dams in Iran to reach a more favorable statistical method.

6. Conclusion

In this study, the hydraulic properties of the

Taleghan River in the examined scale (i.e., 22 km long) at the stations downstream of Taleghan Dam were used to determine the flow rates of the river hydraulically. Afterward, the obtained discharge values (Table 2) were compared to determine the adequacy of river flow to supply the sanitary water (tables 3 and 4). Since the difference between the maximum measured value of the acidity parameter (pH) was equal to the acidity value of 8.640 (station 3), the standard value of this parameter in rivers was 8 at maximum, which was equal to the acidity of 0.640. Consequently, according to the proposed model, the minimum flow of sanitary water was 1.82 (m^3/s), and the water release less than 1.82 (m^3/s), as the minimum sanitary water flow, was not allowed in any month of the year.

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