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A Comparison of water quality indices for Haraz River

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Abstract

Rivers are considered as the most sustainable and clean water resource in all over the world. However, increasing the population and urban development make them to loss their sustainability. Therefore, quality control of these resources is an important task of environmental engineering. Given the importance of the Haraz River in water withdrawals for different uses and discharging different pollutants into it, mentioned river water quality assessment is essential. Parametric water quality measurements are difficult, in the other word, time consuming and costly. Three valid Quality Indexes namely National Sanitation Foundation Water Quality Index (NSF-WQI), Orgon Water Quality Index (O-WQI), and Universal Water Quality Index (U-WQI) are applied to assess the Haraz River water quality. Water quality has been assessed in a seasonal and annual basis at 10 stations. The findings indicated that water quality in Haraz River on average are good, very bad and relatively good in spring, summer, autumn and winter. Jill Janoik comparison method was used to compare the mentioned indices. The results of comparison indicated that the Oregon index is introduced as the most appropriate environmental quality index for monitoring and evaluating the Haraz River water quality.

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Introduction

Water in the initial creation is created clean and free from any contamination but human development and societies industrialization causes different pollutants enter into the human environment, particularly water resources that decrease its quality (AmirBeygi, 1383). Access to clean and fresh water is one of the most important issues for today human (Maknun, 1382). Rivers as a major source of water supply for various uses includes agriculture, drinking, and industry be discussed. Given to the importance of this channels and droughts in recent years, protecting these resources is one the most important task. On the other hand, these resources are used as a place for discharging sewage, wastewater of factories, agricultural drainage. So today, qualitative and environmental examination of these resources is discussed and the most contaminated areas should be identified by water quality parameters (Nazari *et al.,* 2005).

Optimal utilization of water resources (Maknun, 1382), knowing, and qualitative and quantitative examination of water resources, preventing water resources pollution and renewable resources are essential element of sustainable development (Kamali and Esmaeili Sari, 1388). Monitoring and controlling of surface water are considered necessary and essential for different uses in order to high quality water will be available to consumers for various uses (Samadi *et al.,* 1388, Najah *et al.,* 2009). Studying river water quality is the first and most important steps in management of river water quality because it clarifies the process and pollution changes over time, place, and circumstances to analysts (Norouzyan *et al.,* 1388).

Examination of rivers water quality is conducted in different countries through different ways. Laboratory analysis is one of the methods to assess water quality. High expenditure and time consumption are the main problems of this method due to large number of parameters and samples (Najah et al., 2009, Razzaz et al., 2007).

With technology development, more information is provided easily and during the shorter time. The information of surface water must be processed and the summarized result should be offered to experts for various applications. Water quality index is a very simple method free from mathematical and statistical complexities that can iterate the water quality conditions. Pollution quality indexes are methods that can be used for water quality management as a powerful management tool to make related decisions (Samadi *et al.,* 1388, Najah *et al.,* 2009, Norouzyan *et al.,* 1388). Most of the studies in Iran are on the rivers water quality changes and the quality index studies are less (Kermani and Naseri, 1391, NikooNahad *et al.,* 1388). The indexes show the water quality as well as the process of water quality changes through the time and place by simplicity and decreasing initial information (Abbasi, 2000).

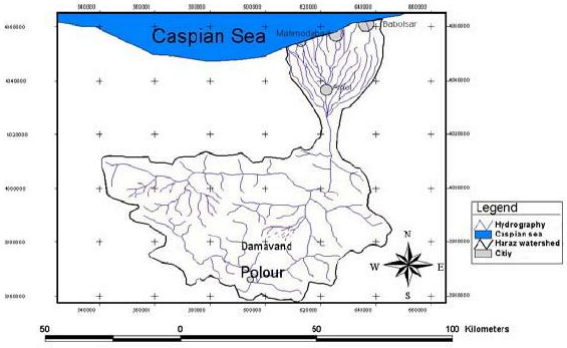

Fig. 1. Description of the study area: a basin map of Haraz River (EPA 2008).

Known water quality indexes are used for studying Haraz River water quality as a suitable method to determine quality changes because of its easiness and the results are simplified and mentioned understandably. After preliminary analysis and gaining information from initial studying, the parameters adapted to the research objectives were chosen. Most of the selected parameters are considered as common qualitative parameters in monitoring and assessing the water resource in which most of them are applied as a crude variable in the structure of water quality indexes (NSF-WQI, U-WQI, and O-WQI). All of the applied water quality

indexes are the valid ones and most of the sub-indicators are common among them. In addition, the range of changes is all from 1 to 100 (the worst case is related the number 1 and number 100 is for the best case) (NikooNahad *et al.,* 1388). Using the mentioned indexes is very common and is considered complete and comprehensive indexes for surface water classification from drinking sense. By applying them, suitable perspective toward the rivers water quality may be provided (AmirBeygi, 1383, Samadi et al., 1388, Kumar et al., 2011, Nazari et al., 2005).

Description of the study area

Haraz River is one of the important rivers in Caspian Sea basins and is the most watery river in the west of Mazandaran. The mentioned river is one of three moist rivers in the country (AhmadiMousavi, 1381, Afshinnejad, 1373, Molazade, 1384) that originated from the eastern slope of Paloun Gardan Mount, 80 km southwest of Amol and 70 kilometers southwest of the Nour. It is named Lar River to Plure area, after that it is called Haraz (AhmadiMousavi, 1381, RoshanTorabi, 1370). This river is one of the Mazandaran province's permanent rivers that divide Amol in East and West section. Haraz River length and Basin area are respectively about 185 km and 5100 square kilometers that is loacted in the northern part of the Alborz Mountains, 35º 45´ to 36º 42´ north latitude and 51º 27´ to 52º 42´ Eastern (IjadPanahSarvari and Kiani, 1391, Molazade, 1384).

Haraz River is one of the most important rivers in Northern provinces that its life is threatened by increasing the pollution in the river. To compare water quality indices in the Haraz River, seasonal sampling of 10 stations has been used (EPA, 2008). Haraz River Basin is shown in Fig. 1.

Material and methods

Water quality indexes

In this study, in order to analyse the water quality, 3 water quality indices; U-WQI, O-WQI, NSF-WQI, is used in every station. For calculating indices, sub-indices equation and weighting factors parameters have been used.

National Sanitation Foundation' WQI (NSF-QWI)

National Sanitation Foundation was presented based on surveying experts in this area in 1970 by Brown et al. NSF-WQI' parameters include pH, Disolved Oxygen (DO), turbidity, Fecal Coliform (FC), Biologycal Oxygen Demand (BOD), Total Phosphate (TP), Nitrate (TN), Temperature change, and Total Suspended Solids (TSS) (Razzaz et al., 2007). Equation 1 is used to calculate NSF-WQI.

$$NSF - WQI = \frac{\sum Q\ value \times Weight}{\sum Weight}$$

In this equation, NSF-WQI= Index of National Sanitation Foundation, Q= qualitative parameter value and W= weight of parameters are considered. NSF-WQI can be calculated by using sub-index equation of each parameter and their weighte. After evaluating the considered index, water quality can be ranked relating it to a descriptive category (Kumar et al., 2011).

Oregon' WQI (O-WQI)

Oregon Water Quality Index was achieved in early 1970s and developed according progresses scientific related to water quality. This index is a single number that is calculable by using eight water quality parameters such as Temperature, Disolved Oxygen (DO), Biologycal Oxygen Demand (BOD), pH, Fecal Coliform (FC), Ammonia+ Nitrated Nitrogen, Total Solids (TS) and Total phosphor (TP). The equation of Oregon index is as follow (Cude, 2001, Razzaz et al., 2007).

$$O - WQI = \sqrt{\frac{n}{\sum_{i=1}^{n} \frac{1}{SI_i^2}}} = \left(8/\left(\frac{1}{SI_T^2} + \frac{1}{SI_{DO}^2} + \frac{1}{SI_{BOD}^2} + \frac{1}{SI_{pH}^2} + \frac{1}{SI_{TS}^2} + \frac{1}{SI_N^2} + \frac{1}{SI_P^2} + \frac{1}{SI_{FC}^2}\right)\right)^{1/2} \quad (2)$$

In this equation, SIi= sub-indices of qualitative parameters, n= number of sub-indices, and O-WQI= Oregon water quality index are considered.

Oregon water quality sub-index for each qualitative parameter can be calculated. After calculating the mentioned index, water quality can be ranked relating it to a descriptive category.

Universal WQI (U-WQI)

Universal Water quality Index is made up 12 parameters, which include BOD, Nitrate, Arsenic, DO, Fluoride, Total Phosphate, Mercury, Selenium, Cyanide, Cadmium, Fecal Coliform (FC) and pH. Equation 3 is used to calculate U-WQI (Boyacioglu, 2006, Kumar et al., 2011).

$$U - WQI = \sum_{i=1}^{n} \frac{\text{WQI calculated}}{\text{Weight used}} \quad (3)$$

In this equation, U-WQI= Universa Water Quality Index, Q= qualitative parameter value and W= weight of parameters are considered. U-WQI can be calculated by using sub-index equation of each parameter and their weighte. After evaluating the considered index, river water quality can be identified relating it to a descriptive category.

Comparison of Water Quality Indices

The considered indices were compared by using comparative method of Gil Janovic to determine the best index for Haraz River. In this method, indices are faced two by two and a separator line splits the conjunction axis of two indices. In mentioned method the index that the most points are placed inside separator line will be considered the best, because in this way summation and average of differences in this index is much more than the second index which the most points are placed outside separator line. Therefore, first index can represent the water quality changes better than second index (NikooNahad *et al.,* 1388).

Results and discussion

All parameters of NSF-WQI are available. Water quality index of Haraz River is presented in Figure 2 for 10 stations in spring, summer, fall, and winter. According to NSF-WQI classification, water quality of Haraz River is 75 on the average, which is in good ranking. Based on results of NSF index, summer and winter had the lowest and the highest index respectively in terms of health condition. Quality index in station 1 indicates higher value comparing other stations; therefore, the quality of water is better in station 1.

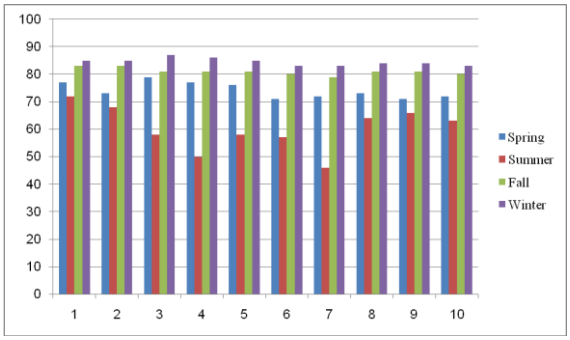

Fig. 2. NSF-WQI for stations of Haraz River.

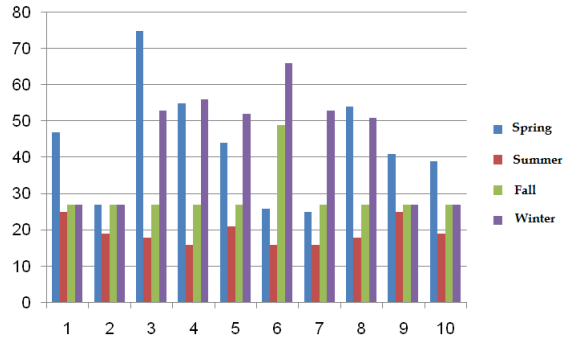

Fig. 3. O-WQI for stations of Haraz River.

According to the available water quality data, O-WQI of Haraz River is presented in Figure 3 for 10 stations in spring, summer, fall, and winter. Based on O-WQI classification, water quality of Haraz River is 34 on the average, which is in very bad ranking. O-WQI is shown that summer and winter had the lowest and the highest index in terms of health condition, respectively. Quality index in station 3 indicates higher amount comparing other stations; therefore, the quality of water is better in station 3.

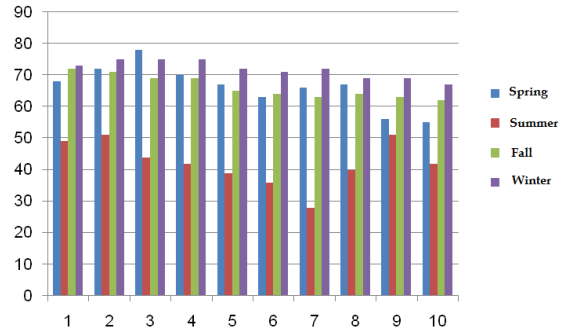

Fig. 4. U-WQI for stations of Haraz River.

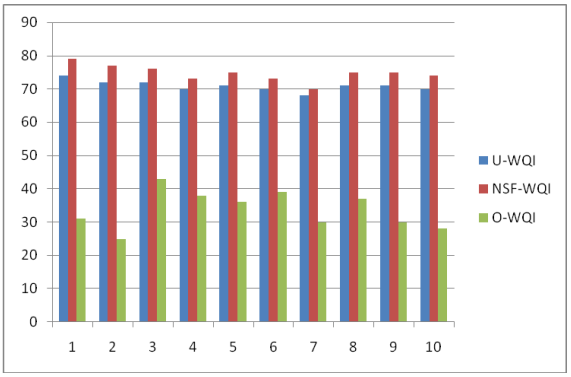

Fig. 5. comparison of 3 WQI for 10 stations of Haraz River.

According to the available data, among 12 parameters only six parameters of U-WQI are available. U-WQI of Haraz River is presented in Figure 4 for 10 stations in spring, summer, fall, and winter. Water quality of Haraz River is 71 on the average, which is in relatively good ranking according to U-WQI classification. Based on U-WQI results, summer and winter had the lowest and the highest index in terms of health condition, respectively. Quality index in station 1 indicates higher amount comparing other stations; therefore, the quality of water is better in station 1.

The water quality of Haraz River, was examined in 10 stations by using three indices; U-WQI, O-WQI, and NSF-WQI. The examinations revealed that the Haraz River water quality classified in good, very bad, and relatively good respectively on the average. Comparision of mentioned WQI for Haraz River is presented in Fig. 5.

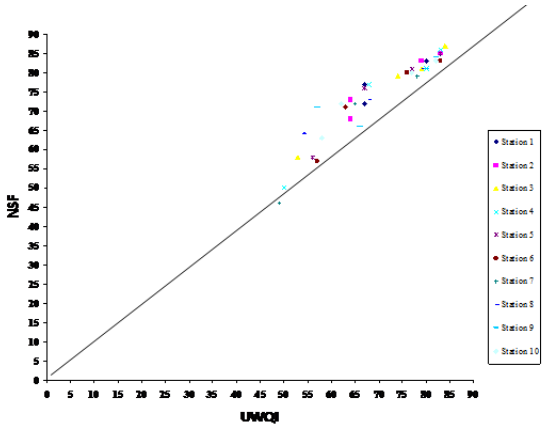

Fig. 6. Comparison of U-WQI & NSF-WQI in selected stations of Haraz River.

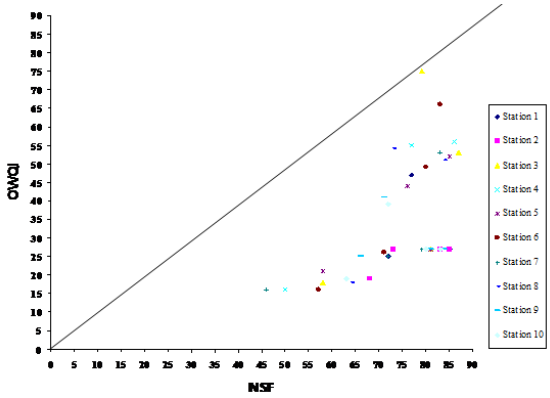

Fig. 7. comparison of NSF-WQI & O-WQI in selected stations of Harza River.

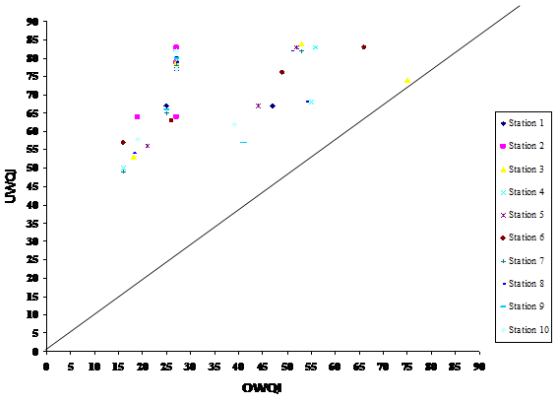

Fig. 8. comparison of U-WQI & O-WQI in selected stations of Harza River.

In Fig. 6, NSF-WQI has been compared with U-WQI in selected stations in different seasons. It can be seen that most of the points are under the separator line, therfore; U-WQI shows the qualitative alterations better than NSF-WQI. It means dispersion and summation of numbers interval is much more in U-WQI than NSF- WQI.

The amount of NSF-WQI has been compared with O-WQI in selected stations in different seasons that is presented in Fig. 7. Most of the points are under the separator line; therfore, the qualitative alterations are shown better in O-WQI. It means, dispersion and summation of numbers interval is much more in O-WQI.

In Fig. 8, U-WQI has been compared with O-WQI in selected stations in different seasons. It can be seen that most of the points are under the separator line; therefore, O-WQI shows the qualitative alterations better than U-WQI. It means dispersion and summation of numbers interval is much more in O-WQI than U- WQI.

Conclusion

The water quality of Haraz River, by using 3 indices; U-WQI, O-WQI, and NSF-WQI is good, very bad, and relatively good respectively, on the average. One reason for difference in WQI ranking results is the difference on standard values. In addition, lack of input data related to indices can be another reason of difference in the water quality results of Haraz River. Furthermore, the effect of sub-indices weight for each index might be considered for estimating WQI. According to the results of three WQI, in spite of the fact that the results of the U-WQI, and NSF-WQI represent the alterations in different situations almost the same, but because of not using all parameters in calculating U-WQI, it seems that NSF-WQI is a better index for evaluating WQI. According to the systematic comparison of indices from Fig. 5 to 7 which is mentioned above, it is concluded that O-WQI is the best environmental quality index for monitoring and evaluating of Haraz river water quality.

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