RESEARCH ARTICLE

• Arch Hyg Sci 2012;1(1):20-25
• Journal homepage: http://jhygiene.muq.ac.ir

Application of Water Quality Index for Quality Zoning

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A-R-T-I-C-L-E I-N-F-O

Article Notes:
Received: Mar 17, 2012
Received in revised form: Jul 17, 2012
Accepted: Jul 30, 2012
Available Online: Sept 2, 2012

Keywords:
Alborz Province, Karaj, Iran
Lakes, Karaj Dam
Quality Control
Quality Zoning
Rivers, Karaj
Water Quality, Assessment
Water Quality, Index

A-B-S-T-R-A-C-T

Aims of the Study: The physical, chemical and biological characteristics of Karaj River (near the city of Tehran, Iran), has been studied to evaluate the suitability of its water for domestic uses.

Materials & Methods: Samples of water were collected from various localities before, in and after Karaj Dam Lake and were analyzed based on needs for Water Quality Index (WQI) calculation. In this study, WQI were calculated for the best and the poor condition for quality zoning determination of Karaj water quality.

Results: Comparison of water quality index in different sampling stations of Karaj River in different years showed that the water quality of this river was better in 2008 compared with years 2007 and 2009; however ANOVA analysis showed no significant difference between the data in these years ($p < 0.05$).

Conclusions: The range of water quality was different from medium to good (WQI=50-100), so this water can be used for domestic uses after suitable treatment.

Please cite this article as: Dehghanifard E, Baneshi MM, Badalians Gholikandi G, Dehnavi A, Asgari AR, Khazaei M, Yari AR. Application of water quality index for quality zoning. Arch Hyg Sci 2012;1(1):20-5.

Background

River water is the major source for many activities such as drinking, and agricultural and industrials uses.

Due to increasing industrialization and urbanization, river water pollution is becoming severe problem. So some tools must be developed to keep watch on such pollution (1).

Several water quality indices have been developed to evaluate water quality. Some of the water quality indices that have been frequently employed in public domain for the purpose of water quality assessment are the National Sanitation Foundation Water Quality Index (NSFWQI), British Columbia Water Quality Index (BCWQI), Canadian Water Quality Index (CWQI), Oregon Water Quality Index (OWQI), and the Florida Stream Water

Quality Index (FWQI). Among them, the NSFWQI has been the forerunner of many indices and its methodology continues to be adapted (2).

Water quality Index is simpler and convenient tool to express quality of water. It gives immediate idea about pollution of the water body. Such WQI will give idea concerning increase or decrease in pollution rate for the water body under consideration. Monthly, seasonal or yearly changes in the water quality can be quickly assessed with help of such Index (3). These changes may be used for a fixed point during time or for various points in the fixed time.

Karaj River, the most important drinking water resource of city of Tehran has faced many environmental accidents and problems, so its water quality may be degraded. It is obvious that river quality has changed between the best and worst range of quality condition.

The quality zoning and level determination of rivers allow experts to make a proper decision for best and worst quality condition of considered rivers. In the other words, quality zoning could demonstrate maximum and minimum quality changes of river in each station during a year and proper decisions could predicted for critical quality conditions.

Aims of the Study: In this study, water quality of Karaj River before and after Karaj dam and its lake has been assessed using WQI method to determine water quality of this river after and before dam, role of lake in pollution adjustment and determine the water quality in maximum and minimum value in various points and in various years for quality zoning determination. For this reason, after data collection and analyzing, WQI was calculated and draw for minimum, average and maximum data in length of river (1).

Materials & Methods

Site Specification: Water supply for Tehran's residents is supplied from the Karaj and Jajrood Rivers and from groundwater resources. At present, about 60% of drinking water supplies are provided by Karaj, Latyan and Lar dams near Tehran (4). Thus, Karaj River is the most important source of water supply for Tehran Province.

Karaj River: Karaj River, one of the most important rivers of central watershed, is located in the northwest of this watershed and is one of the most important rivers of Iran.

The most flow of Karaj River and its branches is applied for agricultural, municipal and industrial uses of Tehran Province (including Tehran, Karaj, Damavand, Varamin and Shahriar), and the remaining flow enters to Qom Salt Lake. The Karaj surface watershed encompasses more than 5000 km^2 with annual average precipitation of 700 mm.

Data collection: In this research, some physicochemical and bacteriological data, routinely experimented each month by Tehran Water and Wastewater Company, were used to evaluate the water quality and quality zoning of the Karaj River. These data consisted of 9 parameters, based on WQI method as follows:

- Dissolved oxygen (DO),
- pH,
- Biochemical oxygen demand (BOD_5),
- Temperature (T^o),
- Turbidity,
- Total solids (TS),
- Nitrate (NO_3),
- Phosphate (PO_4),
- Fecal coliform (FC) bacteria.

All samples were analyzed in accordance with American Public Health Association (APHA) methods (5).

To monitor water quality, Tehran Water and Wastewater Company has selected 20 stations along Karaj River but we used only 12 stations in this study due to their importance for pollutants entrance and more complete data.

Analyses and water quality data interpretations of this river were carried out in a period of three years (from April 2006 to March 2009) and were applied by WQI index

calculator and Excel software. Data of this period were available monthly except in spring and summer of 2007 that were seasonally.

To provide a standardized method for the NSFWQI, 142 Iranian researchers in the water quality field surveyed about 35 parameters. In the final form, NSFWQI relied on nine parameters: DO, fecal coliform bacteria, pH, biochemical oxygen demand (BOD_5), temperature, total phosphate, nitrate, turbidity, and total solids (2, 6). In NSFWQI method, values ranges from 0–100 and waters are classified as very bad (0-25), bad (25-50), medium (50-70), good (70-90), or excellent (90-100).

Data analysis: In WQI calculation, weighting averages of parameters required for WQI should be calculated, and then sub-index of each parameter must be determined based on specific charts and, finally WQI of each sampling point determined by multiplying sub-index to weighting average of each parameter.

Table 1 shows weighting factor and WQI calculation of each parameter. In Table 2, different water quality ranges have been categorized by different colors (7, 8).

The Calculating NSF Water Quality Index software was used for sub-index and WQI determination of this study that was in Wilkes University webpage (9).

Table 1) Parameters and weight factors for Water Quality Index (WQI) calculation

Parameter	Weight factor
Dissolved Oxygen	0.17
Fecal coliform bacteria	0.16
pH	0.11
Biochemical oxygen demand	0.11
Nitrate	0.10
Phosphate	0.10
Temperature	0.10
Turbidity	0.08
Total solids	0.07

Table 2) Colors and definitions for Water Quality Index (WQI)

Color	WQI	Definition
Red	0-25	very bad
Orange	26-50	bad
Yellow	51-70	medium
Green	71-90	good
Blue	91-100	Very good

Results

Based on parameters of WQI of considered stations and specific software for sub-index and WQI calculation, the best and worst quality condition of Karaj River from April 2006 to March 2009 were determined (Table 3). By using these results, the quality zoning of Karaj River during studied time is applicable.

The most important sampling station in Karaj River is station No. 12 (Bilaghan) that supplies drinking water of Tehran. The water quality index in this station was not reduced less than average and was not increased more than good condition.

Amounts of water quality index in 2007, 2008, and 2009 were 65, 69, and 65 in minimum; 84, 83 and 84 in maximum; and 74, 79 and 75 in average, respectively. Those amounts showed that the average of water quality index in that station always were in good condition (WQI=71-90) that could be suitable for domestic uses, after treatment.

Figures 1 to 4 demonstrate water quality changes of Karaj River in 2007, 2008 and 2009 wet seasons, based on Table 3. As can be seen, the minimum water quality of Karaj River were in medium range (WQI=51-70) and sometimes good (WQI=71-90) in all considered stations during 2007-2009 wet seasons and no bad water quality condition (WQI=26-50) had been detected.

Moreover, results showed that the maximum water quality in no station reduced from good

quality (WQI=71-90) and occasionally reached excellent quality (WQI=91-100) too.

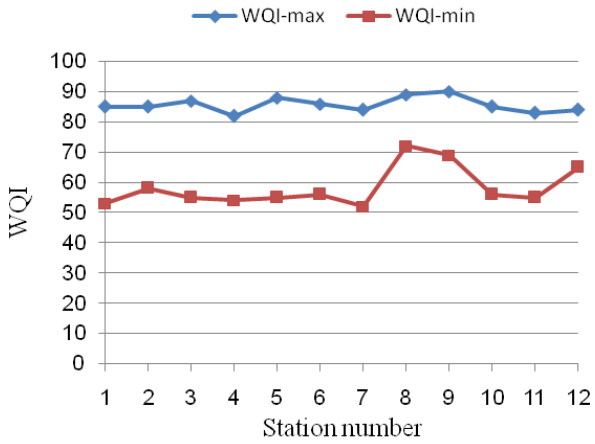

Figure 1) Minimum and maximum Water Quality Index (WQI) for Karaj River in 2007

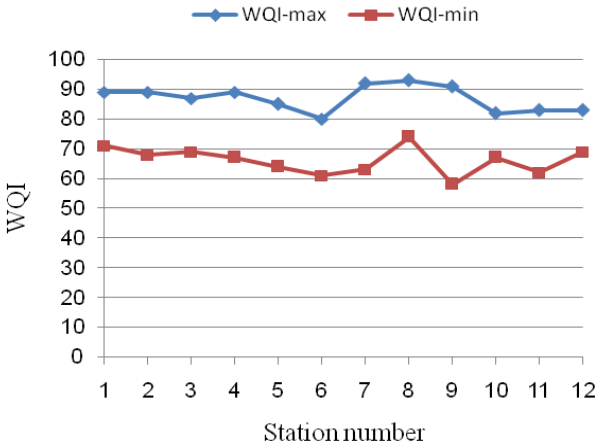

Figure 2) Minimum and maximum Water Quality Index (WQI) for Karaj River in 2008

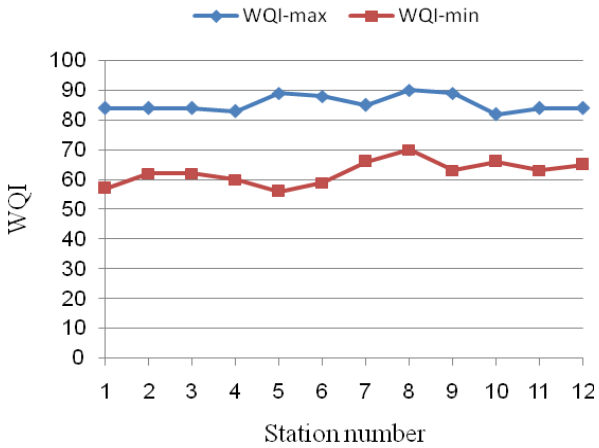

Figure 3) Minimum and maximum Water Quality Index (WQI) for Karaj River in 2009

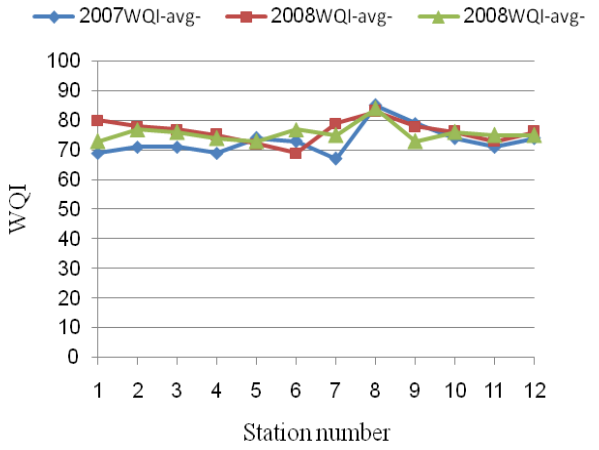

Figure 4) Average of Water Quality Index (WQI) for Karaj River in 2007, 2008 and 2009

Table 3) Minimum, maximum and average of Water Quality Index (WQI) for Karaj River in 2006, 2007, and 2009

Station number	WQI-2007			WQI-2008			WQI-2009		
	min	avg	max	min	avg	max	min	avg	max
1	53	69	85	71	80	89	57	73	84
2	58	71	85	68	78	89	62	77	84
3	55	71	87	69	77	87	62	76	84
4	54	69	82	67	75	89	60	74	83
5	55	74	88	64	72	85	56	73	89
6	56	73	86	61	69	80	59	77	88
7	52	67	84	63	79	92	66	75	85
8	72	85	89	74	83	93	70	84	90
9	69	79	89	58	78	91	63	73	89
10	56	74	85	67	76	82	66	76	82
11	55	71	83	62	73	83	63	75	84
12	65	74	84	69	79	83	65	75	84
Average	58.33	73.08	85.58	66.08	76.58	86.92	62.42	75.67	85.50

STDEV	±6.58	±4.89	±2.27	±4.58	±3.84	±4.25	±4.03	±2.99	±2.71

Discussion

By comparison the WQI for different stations in different years, it could be concluded that the water quality of Karaj River in 2008 was better than 2007 and 2009; however, the quality changes of this river in different years were not considerable. According to Table 3, the WQI averages of Karaj River were 77.08±4.89, 76.58±3.84, and 75.67±2.99, respectively for years 2007-2009.

Results showed that the lake Karaj dam placed between stations 7 and 8, played an important role in pollutants level reduction and increasing in the considered index which could be more deduced in low quality conditions. It means that the lake of Karaj dam had more effects on pollutants reduction and increasing in WQI in lower water quality. This matter can be concluded from water quality trends of Karaj River in studied years.

This study shows that the water quality index of Karaj River was in good condition for almost all sampling stations in all considered years and just in 2007 and few stations was in average ranges. The Lake of Karaj River has important and considerable effects in water quality improvement of Karaj River which the water quality index amounts were in good condition and the best water quality of Karaj River was occurred in this zone due to concentration shock regulation of pollutants, water staying and suspended solids sedimentation, less water temperature changes, *etc*.

Conclusions: In this study, new method was created for quality zoning of rivers by application of water quality index that the best and worst water quality of each station could be determined and then necessary solutions would be predicted and applied for each condition. By applying this method for Karaj River and assessment of nine quality parameters of WQI, it is concluded that the water quality of Karaj River was not reduced below average condition in studied years. The water quality index of Karaj River showed that the lake of Karaj dam plays a important role in quality improvement of this river which the WQI amounts were in good condition and the best water quality of Karaj River was occurred in this zone due to concentration shock regulation of pollutants, water staying and suspended solids sedimentation, less water temperature changes, *etc*.

Footnotes

Acknowledgments:

The authors acknowledge the Iranian Water and Wastewater Company and the Water Research Institute authorities for their supports of this study.

Funding/Support:

This study has been financially supported by the Water Research Institute (WRI), Tehran, Iran.

Conflict of Interest:

The authors declare no conflict of interest.

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