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Water Quality Classification of the Karaj River Based on a Biological Index

Seyed Hadi Khatami*

Division of Human Environment, Department of the Environment, Bureau of Environmental Impact Assessment, Tehran, Iran

Abstract

The Karaj River is one of the most important rivers in Iran that provide potable water for Tehran City. The purpose of this study was to determine the water quality of the Karaj River based on the BMWP biotic index along the river from Gachsar village to the Amirkabir Dam. Four Phyla, 4 Classes, 4 Orders and 21 Families of macro-invertebrates were identified via the collected samples. There was a significant difference (P=0.03; n=4) between the BMPW indices recoreded during summer and autumn. This could be due to decreasing chanel size and differences in the discharge of pollutants between the two seasons. The result of cluster analysis showed three distinct groups of sites. The results of the biological survey showed that, although the quality of the water is influenced is pollution, the impact is not at the level that could seriously the use of the river water for potable consumption.

Keywords

Karaj River, Macro-Invertebrates, Biological Monitoring Working Party (BMWP) Index

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1. Introduction

Water is the most vital element for life forms on earth. Freshwater is an increasingly scarce resource throughout most of the World and is likely to become evermore so as global warming and the growth in human population continue to take effect. This most valuable element is a highly vulnerable resource, particularly for countries located in arid areas and especially for a vast country like *Iran*. It is, therefore, necessary for our present freshwaters to be managed efficiently and sustainably to provide the water needed for agricultural, industrial and potable use. It is recognized increasingly, that, for economic, aesthetic, moral and biological reasons (Begon, Harper and Townsend, 1990), this management must have as little adverse impact, as possible, on the natural environment.

One of the major sources of water for *Tehran* (the capital city of Iran) is the *Karaj River*. This river is one of the main and most important rivers in the central and southern Alborz basin. It supplies potable, irrigation and recreation water for the capital city which has the Karaj River system about one sixth of the country's population (Figure 1). It originates from the north and south Asara mountain ranges and passes at 42 km and confluent with Shahrestanak and Sedic rivers join to the Amirkabir Dam. The river after the dam is eventually joined by Salt Lake. Its system can be classified in the general regime of snow - rain (Nivopluvial). Rain in the region (600-700 mm annually falls for almost 7 months from November to the end of May. August rainfall is minimal. The Karaj river basin is a mozaic of Paleozoic, Mesozoic and Tertiary geology. The water quality according to the type of use and its environment has been reported by Egglishaw (1980). The river is threatened by several point sources as well as by differe sources of pollution. The main sources of pollution in the Karaj are:

1. Wastewater from villages bordering the river.

2. Farm wastes (wastewater and solid wastes).

* Corresponding author
E-mail address: Seyedhadikhatami@Yahoo.com

3. Sewage from a military garrison.

4. Waste from public places of entertainment, hotels, camps and residential areas.

5. Slaughterhouses.

6. Sewage from factories and workshops

The purpose of this study was to determine the water quality of the *Karaj River* based on the BMWP biotic index (National Water Council, 1981). The biotic index and required capabilities necessary for the river ecosystem management plan have been studied and the recommendations to improve the water quality are listed later in this paper.

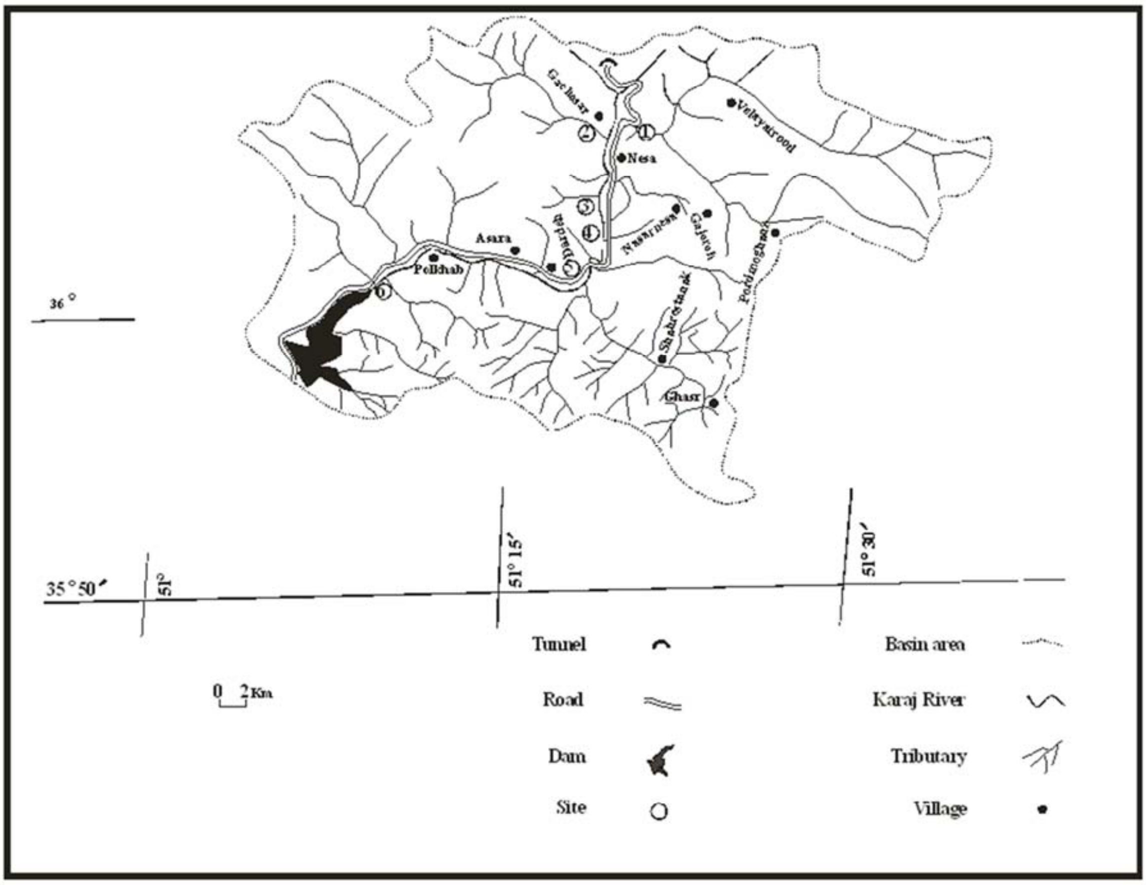

Figure 1. Map of study area.

2. Materials and Methods

Sampling macro-invertebrates

The survey was carried out in the Alborz Province of Iran (Figure 1) where the main part of the river is located. For our investigation, 6 sites were chosen (Figure 1) on the basis of permanency and accessibility from Gachesar to the dam.

At each site, a three-minute kick sample was collected from a riffle area because riffles generally support a more diverse benthic macro-invertebrate fauna than do pool areas (Hynes, 1970) and hence have greater information content. Therefore, changes in the composition of the riffle fauna provide a more sensitive measure of environmental differences between sites (Learner *et al.,* 1983). A 500 mesh pond net with a 30×30 cm mouth was used.

Each sample unit was transferred to a plastic container and preserved immediately with formaldehyde solution. Later, the sample units were washed through a 500μm mesh sieve and the retained macroinvertebrates were spread over a large tray for sorting. Animals that were seen easily were picked out and then smaller animals were removed aided by the use of a low power microscope. All animals were transferred to vials containing 70% ethanol plus glycerol. Individuals were identified as far as possible, usually to family.

Biotic Index

Several different approaches have been used to assess water quality based on macro-invertebrates. Through the list of macro-invertebrate species and their relative or absolute abundance one is able to make a significant assessment of the river water quality (Dussart *et al.,* 1980). These data are often reduced to a simple numerical index that takes account of the sensitivity or tolerance of individual speceis or groups to pollution, usually organic pollution. A potential advantage of using biotic indices based on the benthic macro-invertebrates is that the score not only reflects water quality but also reflects changes in the nature of the substratum that may also be pollution-induced. A number of such biotic indices have been developed to assess water quality (Beck, 1954; Pantle & Buck, 1955; Goodnight & Whitley, 1960; Woodiwiss, 1964; Brinkhurst, 1966; Chandler, 1970; Balloch *et al*., 1976; Abel, 1980; Washington, 1984; Hellawell, 1986; Hilsenhoff, 1988; Mason, 1991; Whitehurst, 1991).

The Biological Monitoring Working Party Score is one pollution index that has been widely used in Britain (Abel, 1989). In the present, the BMWP Index has been applied to evaluate water quality of the Karj River because:

1) Of the presence of pollution particulerly biodegredable organic pollution;

2) It requires only qualitative data for calculation;

3) Minimal sampling is necessary;

4) Its use of a low level of taxonomic penetration permitting a rapid assessment;

5) It is applicable to a wide range of waters and geographical areas (Abel, 1989);

6) The sites could be sampled by a kick/sweep metrhod with a standard pond net;

7) The index can be calculated easily.

Statistical analysis

Cluster Analysis (Sokal and Sneath, 1963) was used to group the sites on the basis of the relative quantitative associations amongst their BMWP Scores attributes. It was used the Average Linkage Cluster Technique which takes account of the average scores similarity amongst the sites. Sokal and Sneath (1963) recommended that the simple unweighted arithmetic average (UPGMA-unweighted pair-group method analysis) should be used when there is no specific reason for choosing an alternative technique. The resulting site associations were then displayed as a dendrogram. Classifying the data in this way imposes discontinuities on what may be continuous data (Randerson, 1993).

3. Results

The macro-invertebrates identified from the six sites are given in Table 1. Four Phyla, 4 Classes; 8 orders and 21 Families of macro-invertebrates were recorded overall. The BMWP scores for the study sites are given in Table 2. The greatest score was obtained for Site 1 (BMWP=84) in winter and the lowest score was for Site 4 (BMWP=39) in winter. The highest annual average score was recorded at Site 1 (BMWP=70.5±6.99) and the lowest was at Site 2 (BMWP=61±5.46).

Table 1. The taxa in samples collected from the Karaj River.

Taxa	**Site**					
	1	**2**	**3**	**4**	**5**	**6**
Baetidae						
Baetis rhodani	+	+	+	+	+	+
Heptageniidae						
Ecdyonurus sp.	+	+	+	+	+	+
Ephemerellidae						
Ephemerella sp.	+	+	+	+		
Chironomidae	+	+	+	+	+	+
Elminthidae						
Elmis sp.	+	+	+	+	+	+
Limnius sp.	+			+		+
Gammaridae						
Gammarus sp.	+					
Hydropsychidae						
Hydropsyche sp.	+	+	+	+	+	+
Leptoceridae						
Athripsodes sp.		+				
Leuctridae						
Luctra sp.	+	+				
Limnephilidae						
Halesus sp.	+	+	+	+	+	+
Limnephilus sp.	+	+	+	+	+	+
Allegamus sp.		+				
Beraidae						
Beraea sp.	+		+	+	+	+
Perlidae						
Perla bipunctata	+	+	+	+	+	+
Planariidae	+	+	+	+	+	+
Simuliidae						
Simulium sp. (A)	+	+	+	+	+	
Simulium sp. (B)	+		+		+	
Siphlonuridae						
Siphlonurus sp.	+					
Taeniopterygidae						
Taeniopteryx sp.	+	+	+	+	+	+
Tipulidae						
Dicranota sp.	+	+	+	+	+	+
Tubificidae						
Tubifix sp.	+	+	+	+	+	+
Naididae						
Nais sp.	+	+	+	+	+	+
Pristina sp.	+	+	+	+	+	+
Lumbricidae						
Eiseniella tetraedra	+	+	+	+	+	+
Viviparidae						
Viviparus sp.						
Number of taxa	23	20	19	19	18	17

Table 2. BMPW score (±SE) in four seasons in the Karaj River.

Annual average	**Season**				**Site**
(n=4)	**Winter**	**Autumn**	**Summer**	**Spring**	
70.5±6.99	84	64	80	54	1
61±5.46	54	59	77	54	2
62.25±7.8	44	59	82	64	3
63±8.5	64	39	79	70	4
62.75±4.7	69	49	69	64	5
64.75±4.1	74	54	64	67	6
	64.83±5.8	50.00±3.6	75.17±2.8	62.17±2.7	

The statistical test (ANOVA) showed that between the spring and summer seasons (P=0.03; n = 4) and between summer and autumn (P=0.006; n=4) there are significant differences between the BMWP scores. No significant difference between sites was calculated. The dendrogram constracted for the similarity coeficients for the four sampling occasions is shown in Figure 2. It revealed a marked discontinuity among the sites. Site 1 was separate from the other sites. The result showed three distinct groups of the sites:

1 - Site 1

2 - Sites 2 and 3

3 - Sites 4, 5 and 6

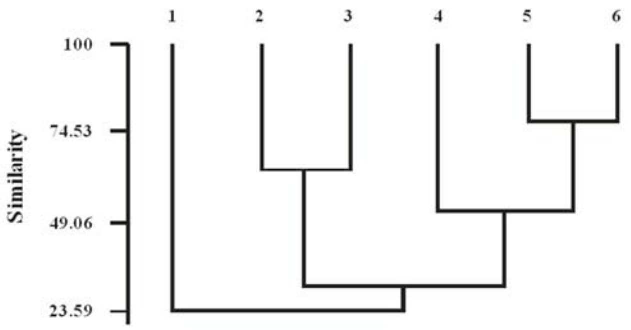

Figure 2. Denderogram representing the grouping of the BMWP of the Karaj River sites.

4. Discussion

The study of the river lower sites showed each to support a relatively distinct macroinvertebrate community. Despite having good water quality in different station (Tables 2 and 3) there is different quality of water that is due to different condition of sites. Although the macroinvertebrate faunas of the Sites sampled in the present survey were relatively distinct from one another, a few taxa such as *Athripsodes sp.* and *Siphlonurus sp.* occurred exclusively in Site 1 (Table 1). Presence of significant differences between summer with spring and autumn could result from reduced the entry of pollutants in the summer and autumn. Site 1 is located at a position along the river from the source that is non-polluting sources. It was found that at this Site more and different taxa occurred most of which were indication of good water quality, such as Heptageniidae, Gammaridae, Elminthidae, Beraidae, Siphlonuridae (Table 1). The grouping Sites 2 and 3 is due to receive pollutants from residential and public area wastewater. Separate the stations 4, 5 and 6 of the other stations because there is very low pollution and improve water quality conditions in the end of current behind the dam (Khatami, 2007). The present survey showed that, in general, the site with high score supported a higher taxon richness (Tables 1 and 2). The study of the river sites showed each to support a relatively distinct macroinvertebrate community.

However, it is apparent from the present survey that although each site may provide a relatively uniform environment, they are not differed considerably amongst each other in terms of water quality on the base of BMWP Score (Tables 2 and 3). The study investigated 6 sites along the river from the Gachsar bridge to the dam of Karaj river, that from the chemical and biological point of view point out that impact of pollution sources not to the extent that the major problems for the river are considered. According to the characteristics used to classify BMWP on the basis of similarities amongst their macroinvertebrate faunas macro-invertebrates that can be used to infer the characteristics of river water quality is good. Although the index was used in this study showed good result, but further research will be necessary with the comprising with the others to found the best index for determination of water quality in the river base on biological index.

Table 3. Classification of water quality based on the BMWP score.

Water quality	Score
Poor	25<
Fair	26-50
Good	51-100
Very Good	101-150
Excellent	150>

5. Suggestions

Generally, for stability and protection of the river quality based on the study, the following suggestion can be considered:

1. Residential facilities and Stabilish sewage collection network and transfer residential and agriculture sewage to the dam downstream in order to efficient protect of river flow.

2. Constracting fence as a barrier for vechiles access to the river bank in order to perevent pollution, especially in the summer.

3. The appropriate plant coverage in the river margin for stabilizing of the riverbank. It can lead to protect the river from physical pollution.

4. Collect and transport of solid wastes such as car tyre, cans and plastics, particularly at Sites 2, 3 and 4.

5. Progressive research for finding proper biological index to evalute water quality of the river at any point.

6. Integrate management of the water and approve regulations for protection of the river quality.

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