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Quality Assessment of the Kashaf River in North East of Iran in 1996-2005

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Abstract: The study presents results of the research on water quality of the Kashaf River in the period from 1996-2005. Applied methodology enclosed ten different water quality determinants classifying according to the existing Iranian regulations, as well as the Water quality index. The water quality of the Kashaf River in investigated period has been differed depending on the measuring location and the hydrological situations. As the drinking water source in some part, the Kashaf River had adequate environmental characteristics. The results have been showed that different indicators of river water quality have not the same ecological importance. The water quality index has been suggested as a simple way for the evaluation of water quality monitoring. Also forming the PC register of pollutants is necessary for providing of dequate preventive measures.

Key words: Water quality, river, water quality index

INTRODUCTION

Kashaf River is a water source for the city of Mashhad and it drains some agricultural lands. The River is one of the major river systems in size, habitat diversity and biological productivity. It is the longest and largest river in Khorasan, flowing 310 km from its source. The river basin measures 15409 km^2. Human activities have greatly altered this river ecosystem. Pollutants also enter the river from metropolitan and industrial areas.

River water pollution hinders the socio-economic development of the Iran (Ye *et al*., 2006), discourages tourism and recreation and degrades the quality of life of local people. Khorasan province is not very successful in development of water usage and protection. Water quality near the towns is in particular very low, due to disposal of wastewater treatment plants effluents (Fulvio *et al*., 2006). A comprehensive river water quality monitoring programme is necessary in order to safeguard public health and to protect the valuable fresh water resources (Bartram *et al*., 2002).

Improvement of the river water quality management is still needed in Iran, for a better quality of life of its inhabitants and to line up with the WHO environmental standards.

The Kashaf River, as a water course in densely populated area, is using for water supply, agriculture, fishing and as recreational water. The quality of Kashaf River is influenced by several sources of pollution and absence of enough treatment facilities.

The School of Public Health has been following the quality of the Kashaf River from 1978 in the function of environmental monitoring. The purpose of the work was to presents some results of the surveillance monitoring of the Kashaf River in ten-year period. It was done comparative analysis of the Iranian legislature categorization of the river and Water Quality Index (WQI) method (Azrina *et al*., 2005).

MATERIALS AND METHODS

The methodology of river water quality monitoring conducting by school of Public Health, covers measurements that are applied four times each year, on 10 measuring points, in the period from 1996-2005. Representative monitoring stations were selected covering the specificity of water pollution for Kashaf River.

The well-trained school of Public Health staffs have been collecting water samples. Methods (sampling, handling of samples) used for river monitoring were conformed to the international standards (ISO) or equivalent national methods. Samples were analyzed for parameters, based on procedures of the last edition of Standards methods for the examination of water and wastewater (Arnold *et al*., 2005). It was not possible to present the values of all routine monitored parameters in the study so the set of parameters was chosen as a representative one: Dissolved oxygen, Biochemical Oxygen Demand-BOD, ammonia, pH, temperature, nitrates, total phosphate, suspend solids, conductivity and *E. coli*. *E. coli*, as indicator of the presence of sewage

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and other sources of fecal pollution (Olga and Okaba, 2006). Are measured by counting the number of bacteria colonies that grow from a 100 mL water sample (Maureen and Macqueen, 2004).

In the area of Mashhad city the effect of industry waste waters and municipal waste waters on the river water quality has been highest, so it was presented the data from the monitoring station located before municipal collector.

First, the monitored parameters were interpreted according to the National river water quality standards. In the Regulation, waters have been divided into four classes by their purposes and cleanness extent. First Class waters that may be used in their natural condition for drinking and food production and processing. Second Class waters that may be used in their natural condition for bathing and leisure activities, for water sports; or waters that, by applying common processing methods, may be used for drinking and food production and processing. Third Class waters that may be used in their natural condition for irrigation purposes and after applying common processing methods (conditioning) within industries that do not need waters with drinking quality. Fourth Class waters that may be used for other purposes only after appropriate conditioning. According to the low, the Kashaf River should be mostly in the Class II as shown in Table 1.

The quality of the river was also assessed using a variation of the Water Quality Index (WQI). The WQI is a mathematical method consisting of condensing ten parameters (dissolved oxygen, Biochemical Oxygen Demand -BOD, ammonia, pH, temperature, nitrates, total phosphate, total solids, conductivity, *E. coli*). Each

Table 1: National river water quality standards

Parameters (mg L^{-1})	I Class	II Class	III Class	IV Class
Suspend solids (mg L^{-1})	to 10	to 30	to 80	to 100
DO (% sat/supers)	90-105	75-90	50-75	30-50
	-	105-115	115-125	125-130
BOD5 (mg L^{-1})	to 2	to 4	to 7	to 20
pH value	6.8-8.5	6.8-8.5	6.0-9.0	6.0-9.0
Ammonia (mg L^{-1})	0.078	0.078	0.39	0.39
Conductivity (µS cm^{-1})	400	400	-	-
MPN of *E. coli* (100 mL^{-1})	2000	100000	200000	200000
Nitrogen oxides (mg L^{-1})	10.13	10.13	15.89	15.89
Phosphate (mg L^{-1})	0.005	0.01	0.01	0.01
Temperature (°C)	17.4	17.4	-	-

Table 2: Parameters of WQI

Parameters	Max value qi x wi
Suspend solids (mg L^{-1})	7
Oxygen dissolved (% sat/supers)	18
BOD5 (mg L^{-1})	15
pH value	9
Ammonia (mg L^{-1})	12
Conductivity (µS cm^{-1})	6
MPN of *E. coli* (1000 mL^{-1})	12
Nitrogen oxides (mg L^{-1})	8
Phosphate (mg L^{-1})	8
Temperature (°C)	5
Σqi x wi = WQI	100

Table 3: Example of the value index score for BOD

BOD5 (mg L^{-1})	Value
0-0.9	15
1-1.9	14
2-2.4	13
2.5-2.9	12
3.0-3.4	11
3.5-3.9	10
4.0-4.4	9
4.5-4.9	8
5.0-5.4	7
5.5-6.1	6
6.2-6.9	5

Table 4: Water quality index ranges

91-100	First class
71-90	Second class
41-70	Third class
11-40	Fourth class
0-10	Out of class

For all calculation we used PC with adequate software

parameter should be converting to an index score according to its weight or its participation in water pollution as shown in Table 2.

A maximum weight has dissolved oxygen and a minimum has temperature. For score calculation for each parameter we were used original scotisch tables as shown in Table 3.

The index value for each of the parameter is then combined to obtain the final WQI. The final result was a number between 0 and 100, with higher numbers indicating better water quality.

Arithmetical formulation of water quality index is calculated according to Eq. 1.

$$WQI = \sum_{i=1}^{n} (qi * wi) \tag{1}$$

Where:

WQI = Water quality index, as an unnamed number at the scale from 0 to 100.

n = Number of parameters

qi = Water quality of the appropriate parameter

wi = Weight allocated to the appropriate parameter

Five categories of water quality were possible according to the WQI method as shown in Table 4.

RESULTS AND DISCUSSION

Obtained data from monitoring stations in the period from 1996-2005 were summarized as average values as shown in Table 5.

Mostly, present monitoring station categorized as second class and sometimes as third class (underline). More than 90% of the parameters belonged to second

Table 5: Physicochemical characteristics of Kashaf river water samples (n = 480) at monitoring station in the period 1996-2005

Year	BOD	DO (%)	NH_3 (mg L^{-1})	pH	NOx (mg L^{-1})	Phosphate (mg L^{-1})	SS (mg L^{-1})	T°C	Conduc. (μS cm^{-1})	*E. coli*
1996	2.1	26.25	0.1	7.7	3.3	0.185	20	12	370	$24*10^4$
1997	2.2	27.5	0.4	8.1	2.2	0.184	4	12	370	$24*10^4$
1998	1.1	13.75	0.2	8.3	3.0	0.111	108	14	380	$24*10^4$
1999	1.0	12.5	0.3	8.4	2.7	0.047	4	14	380	$24*10^4$
2000	1.8	22.5	0.3	8.4	1.3	0.148	22	14	380	$24*10^4$
2001	8.0	100.1	2.25	8.3	3.2	0.259	36	14	410	$24*10^4$
2002	4.6	57.5	0.4	8.4	0.9	0.148	46	14	390	$24*10^4$
2003	2.3	28.75	0.39	8.5	0.9	0.111	38	14	390	$24*10^4$
2004	3.5	43.75	0.4	8.4	1.3	0.111	4	14	390	$24*10^4$
2005	8.7	108.7	2.9	8.2	2.9	0.296	4	14	420	$24*10^4$

class. The river Kashaf water quality is said to be good in investigated period and it was used for drinking water supply and fish habitat.

The amount of oxygen used up by the micro-organisms is measured using the Biochemical Oxygen Demand (BOD) test. Namely, any organic waste matter entering a river acts as a food source for the micro-organisms living in the water and these micro-organisms use the dissolved oxygen present in the water. Unpolluted river waters are likely to have a BOD value <3 mg L^{-1} and values above 4.6 mg L^{-1} in the Kashaf river (2001, 2002 and 2005) indicate possible pollution.

Anoxic and anaerobic conditions in the Kashaf river are frequently observed. Oxygen is essential for the survival of fish and other aquatic life and the dissolved oxygen test is one of the most important indicators of pollution in rivers. It can also indicate whether there is excessive plant growth present.

Normally water is 100% saturated with oxygen but if the oxygen is used up, either by polluting material or by plants that live in the water, the oxygen levels can decrease (Bart Vander and Carlo, 2003). If the levels fall too low a fish kill can result. The presence of excessive plant life can result in supersaturation (>100% DO) of the water as oxygen is given off during photosynthesis. There were these conditions in the Kashaf River in 2001 and 2005. This situation is often accompanied by low night-time levels of DO as the plants respire and these can result in fish kills.

Ammonia was present at very low levels (<0.1 mg L^{-1} N) in the Kashaf river only one year. Domestic sewage and animal slurries are high in ammonia, as are some industry processes (Sakka Hlaili *et al*., 2006).

Ammonia levels higher that 0.2 mg L^{-1} N are usually indicative of pollution. The un-ionized form of ammonia (i.e., NH_3 as opposed to NH_4^+) is very toxic to fish. pH is a measure of the acidity/alkalinity of a river and normally varies in the Kashaf river between 7.7 and 8.5 as well as in unpolluted waters.

Nitrate levels in the Kashaf river water vary on an annual basis and are generally lowest in July-August and highest in January-February, but they were never low as in unpolluted waters (<0.05 mg L^{-1} N).

Most of the nitrate found in the Kashaf river comes directly from waste discharges. High levels of nitrate in river waters may indicate recent pollution.

The Kashaf river had relatively high levels of suspended solids and phosphate. Phosphates are occurring naturally in plants and micro-organisms and also in animal wastes, in agriculture fertilizers and in detergents. The significance of phosphorous is that it is essential for the growth of algae and is usually the limiting factor in algal growth (Sakka Hlaili *et al*., 2006).

Temperature is significant because biochemical reactions, e.g., uptake of oxygen by bacteria, proceed more rapidly at higher temperatures. Temperature also affects the solubility of oxygen in water with less oxygen available for aquatic life at higher temperatures. This means the aquatic life is more vulnerable during the summer period when flows are low and water temperatures are high. Elevated temperatures didn't occur in the Kashaf river.

Conductivity is a measure of the amount of material dissolved in the water and an unusual increase in conductivity can indicate the presence of polluting matter.

The Kashaf river is also impacted by fecal contamination. Our study indicates that during ten investigated years our sampling sites are above state target number for fecal coliform, indicating high fecal contamination.

The pollution of the Kashaf River is due to various human activities performed either on the river banks or along the whole water stream of the river or effluent disposal (chemical, machine tool, building material, textile, electric, agricultural, leather industries and farms). All of industry discharge waste water with a large inorganic load directly into the Kashaf without previous enough treatment. The results suggesting the measures needed to clean the water and remove negative impacts caused during the degradation of the Kashaf river basin, but there is the lack money for investment.

It is important to understand that water's class defines water quality goals and standards, not actual water quality. The first Class water does not necessarily have better water quality than second Class water; it just has higher standards to meet because it could support more beneficial uses. So, then the quality of the Kashaf River was estimated by WQI as shown in Table 6.

Multiple constituents are combined and results were a single score for the sample station. In general, the Kashaf river station scoring was in second and third class and in five year did not meet expectations.

A number of indexes have been developed to summarize water quality data in an easily expressible and easily understood format. The Water Quality Index (WQI) has the following advantages compared to state regulation: it uses the most important measurements of water quality; it could identify areas of good, fair and poor water quality that correspond to professional and public opinion and it eliminates subjective assessments and individual biases in assessing water quality. WQI has also some limitations. For example, WQI contains less information than the raw data that they summarize and many useful water quality data (e.g., toxic metals) cannot be met with an index. WQI is most useful for comparative purposes and for general questions. Indexes are less suited to specific questions. Site-specific decisions should be based on an analysis of the original water quality data. In short, an index is a useful tool for communicating water quality information to the lay public and to legislative decision makers; It is not a complex predictive model for technical and scientific application.

Comparison between the state water quality regulations and WQI was made to provide additional information for the further consideration of the river water quality monitoring as shown in Table 7.

Table 6: Estimation of quality for Kashaf river according to WQI (1996 2005)

Year	WQI
1996	75
1997	73
1998	83
1999	76
2000	73
2001	52*
2002	63*
2003	69*
2004	71*
2005	55**

*Third class

Table 7: Comparison of water quality according to the law (National) and WQI

Year	Legal classification of water quality	Water quality based on WQI
1996	II	II
1997	II	II
1998	II	II
1999	II	II
2000	II	II
2001	III	III
2002	III	III
2003	II	III
2004	II	III
2005	III	III

CONCLUSIONS

Our data indicates that water quality conditions in the Kashaf River didn't meet the target water quality standard for II class in all investigated year.

The comparative analysis of the achieved quality data on Kashaf river leads to the conclusions that WQI could be good indicator of river water quality. WQI simply indicates the river water quality and could be quite useful in Iran. We recommend future studies in this field.

The data also show that anthropogenic effect on the water quality of the Kashaf river is expressed in the region of city of Mashhad. Although certain industries in this region were identified as the cause of the water quality degradation of the river, other pollutants such as agriculture and municipal waste water should be taken in consideration. In the future a lot of work will be necessary on making the register of pollutants and water quality inspection of the river Kashaf itself and the waste waters flowing into it.

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