Evaluation of Water Quality of Kosynthos River in North Greece, using Water Quality Indices

Gikas G.D.[1,*], Lergios D.[1], Psomakelis E.[1], Petalas C.[1]

[1] Laboratory of Ecological Engineering and Technology, Department of Environmental Engineering, School of Engineering, Democritus University of Thrace, 67100 Xanthi, Greece

*corresponding author: Georgios D. Gikas: e-mail: ggkikas@env.duth.gr

Abstract
The water quality of Kosynthos river, located in Xanthi Prefecture, Northern Greece, was evaluated using Water Quality Indices (WQIs). A water quantity and quality monitoring program was undertaken from December 2016 to November 2017 on a weekly basis at three stations along the main course of Kosynthos river. Discharge, temperature (T), dissolved oxygen (DO), pH and electrical conductivity (EC) were measured in situ. Moreover, water samples were collected and analyzed for the determination of biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), total phosphorus (TP), and ammonium nitrogen (NH_4-N), according to the standard methods. Anions (i.e., SO_4^{-2}, Cl^-), NO_3-N, NO_2-N, and cations (i.e., Na^+, K^+, Mg^{+2}, Ca^{+2}) were determined using ion chromatography. The applied WQIs were the Canadian (CCME) WQI, the Oregon WQI, the National Sanitation Foundation (NSF) WQI and the Prati's Index of Pollution. According to the CCME, NSF and Prati's WQIs the water quality of Kosynthos river for both monitoring periods (e.g., 1998-1999 and 2016-2017) was classified in the higher quality classes, while according to the Oregon WQI it was classified in the lowest quality class.
Keywords: Water quality index, surface water bodies, water pollution

1. Introduction

Water Quality Indices (WQIs) are tools which aim at assessing the quality status of a water body, based on a system that merges the list of constituents and their concentrations present in the water samples into a single value (Abbasi and Abbasi, 2012). Therefore, the complex data of a water quality monitoring program can be converted into single values, in order the quality to be evaluated and classified in a simple and understandable description such as "good", "marginal" etc. (Gikas, 2017).

The aim of this study is to present the temporal fluctuation of Kosynthos river water quality based on four different WQIs. The implementation of the WQIs was based on water quality data collected during two monitoring programs that lasted, the first from May 1998 to June 1999 and the second from December 2016 to November 2017. The specific objective of the study was to compare the water quality of Kosynthos river between the two monitoring periods using the applied WQIs.

2. Materials and Methods

2.1. Study area and monitoring program

The study area is the Kosynthos river watershed, in Xanthi prefecture, North Greece. The watershed surface area is about 530 km^2 and its greatest part is a mountainous area, while the rest is a cultivated area. The Kosynthos river is approximately 52 km long with southeast orientation crosses the city of Xanthi and discharges to Vistonis lagoon, which is one of the most significant ecosystems of Greece, protected by the Ramsar Convention. There are point and non-point sources of pollution in Kosynthos watershed. The major point sources are untreated domestic wastewater discharges from settlements at the mountainous part and numerous livestock units along Kosynthos river and its tributaries. Regarding the non-point source of pollution in the watershed, the main source of pollution is the agricultural runoff.

To determine discharge and water quality parameters in Kosynthos river, a network of three monitoring stations (named: ST1, ST2, ST3) along the river was installed. ST1 station was installed at the end of the mountainous part of the watershed (just before to the city of Xanthi), providing information about the quantity and quality of the water which downflows from the mountainous area of the watershed. ST2 station was located after the exit of the city of Xanthi. Finally, the monitoring station ST3 was located downstream and near the mouth of Kosynthos river and provides information about the quantity and quality of water before its discharge into the Vistonis lagoon.

The data collection period lasted from December 2016 to November 2017 and the measurements were conducted at approximately seven-day time intervals. Discharge, temperature, DO, pH and EC were measured in situ. Moreover, water samples were collected and analyzed for the determination of BOD_5, COD, TSS, TP, and NH_4-N, according to the standard methods for surface waters. Anions (i.e., SO_4^{-2}, Cl^-), NO_3-N, NO_2-N, and cations (i.e., Na^+, K^+, Mg^{+2}, Ca^{+2}) were determined using ion chromatography.

2.3. Water quality indices

The WQIs applied were the CCME WQI (CCME, 2017), NSF WQI (Brown et al., 1970; Abbasi and Abbasi, 2012), Oregon WQI (Cude, 2001) and Prati's Index of Pollution (Prati et al., 1971). The parameters considered for the computation of all four WQIs are presented in Table 1.

Table 1. Water quality parameters included in each index

Parameter	CCME	NSF	Oregon	Prati's
T (^{o}C)	✓	✓	✓	-
DO (mg/L)	✓ (>5) [a]	✓	✓	✓
pH	✓ (6.5-9)	✓	✓	✓
BOD_5 (mg/L)	✓ (<6)	✓	✓	✓
COD (mg/L)	-	-	-	✓
TSS (mg/L)	✓(<25)	-	-	✓
TS (mg/L)[b]	-	✓	✓	-
NH_4-N (mg/L)	✓ (<1)	-	-	✓
NO_x-N (mg/L)[c]	✓ (<10)	-	-	-
NO_3-N (mg/L)	-	✓	-	✓
IN (mg/L)[d]	-	-	✓	-
TP (mg/L)	✓ (<1)	✓	✓	-

[a] *the number in parenthesis is boundary value used in the computation of CCME (Gikas 2017)*
[b] *TS=total solids*
[c] *NO_x-N=NO_3-N + NO_2-N*
[d] *IN= NO_3-N + NH_4-N*

All four WQIs were computed for all monitoring stations according to the quality parameters available in each survey. In order to calculate the WQIs for the period 1998 to 1999, the water quality parameters, measured during a previous survey conducted by Gikas (2002), were taken into account.

3. Results and Discussion

Figure 1 presents the temporal variation of each WQI quality class at ST3 station during the two periods. In both monitoring periods CCME, Oregon and Prati's WQIs showed a seasonal variation with the lowest values observed during the summer time. For the period 1998-1999 (Figure 1a) CCME, Oregon, NSF and Prati's classified the water quality between 3 and 5, 1 and 2, 3 and 4, and 4 and 5, respectively. Regarding the period 2016-2017 (Figure 1b), CCME, Oregon, NSF and Prati's classified the water quality from 3 to 5, from 1 to 2, from 3 to 4 and from 3 to 5, respectively. According to the results two distinct categories of WQIs are formed. CCME, NSF and Prati's WQIs assessed the water quality for both periods in the upper quality classes and their values ranged mainly between 4 and 5. On the other hand, Oregon WQI assessed the water quality mainly between the lower quality classes.

4. Conclusions

In this study an attempt was made to assess the water quality of Kosynthos river via the implementation of four WQIs. The CCME, NSF and Prati's WQIs indicated that the water quality of Kosynthos river was at the same level in 1998-1999 and 2016-2017, while Oregon WQI showed a quality decrease during the period 2016-2017 compared to the period 1998-1999. The WQIs computed values showed a temporal fluctuation, especially during the summer time, when the lowest values were observed, indicating a seasonal degradation of water quality.

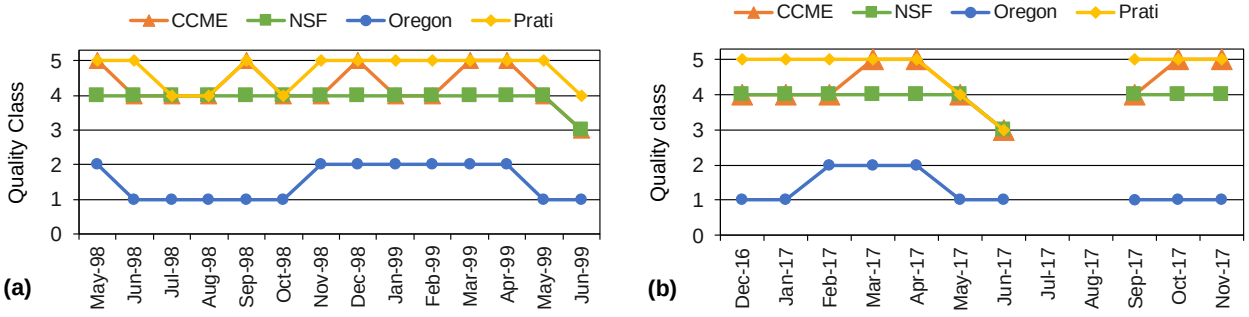

Figure 1. Variation of quality class (1: poor, 2: marginal, 3: fair, 4: good, 5: excellent) in Kosynthos river, based on the four applied WQIs at the ST3 station during the monitoring periods: (a) 1998-1999; (b) 2016-2017

References

Abbasi T., and Abbasi S. (2012), Water Quality Indices. Amsterdam, The Netherlands: Elsevier.

Brown R., McClelland N., Deininger R., and Tozer R. (1970), A water quality index - Do we dare, *Water Sewage Works*, **117(10)**, 339-343.

CCME, (2017), Canadian water quality guidelines for the protection of the aquatic life: CCME Water Quality Index, User's Manual 2017, Canadian Council of Ministers of the Environment. Report, Winnipeg.

Cude C.G., (2001), Oregon Water Quality Index: A tool for evaluating water quality management effectiveness, *Journal of The American Water Resources Association*, **37(1)**, 125-137.

Gikas G.D. (2002), Study of Vistonis Aquatic System. Doctoral Dissertation, Dept. of Civil Engineering, Democritus University of Thrace (In Greek).

Gikas G.D. (2017), Water quantity and hydrochemical quality monitoring of Laspias river, North Greece, *Journal of Environmental Science and Health*, ***52*(14)**, 1312-1321.

Prati L., Pavanello R., and Pesarin F. (1971), Assessment of surface water quality by a single index of pollution, *Water Research Pergamon Press*, **5**, 741-751.