WATER QUALITY INDEX – AN INSTRUMENT FOR WATER RESOURCES MANAGEMENT

PAIU MĂDĂLINA[1], BREABĂN IULIANA GABRIELA[2]

ABSTRACT. Water quality status assessment can be defined as the evaluation of physical, chemical, biological state of the water in relation with the natural state, anthropogenic effects and future uses. Water quality index reduces the number of parameters used in monitoring water quality to a simple expression in order to facilitate interpretation of the data, allowing public access to water quality data.
This study is a summary of an interdisciplinary research program on surface water quality monitoring carried out during the years 2011-2012 in the eastern part of Romania. Water quality index provides a single value expressing the average quality of water at a time, based on analytical values of physico-chemical parameters. For the water quality index calculation were used six physico-chemical parameters: pH, turbidity, dissolved oxygen, biochemical oxygen demand (BOD_5), nitrate (NO_3) and phosphate (PO_4).

Keywords: water quality index aquatic, ecosystems, monitoring.

1. INTRODUCTION

Water is the most important natural resources of the ecosystem, having an important role for both drinking as well economic sectors. In the last century the availability and quality of surface or ground waters has been change, mainly due to urbanization, industrialization etc.

The water quality can be assessed using physical, chemical and biological parameters, the harmful limits of those for human health being establish at international or national scale (WHO, EPA, MECC). The most convenient way to express the quality of water resources for consumption is the Water Quality Index (WQI), using the water quality data being very useful for the modification of the policies. During the years have been formulated several water quality indices by some national or international organization, applied for evaluation of water quality in particular cases. The WQI has the capability to reduce the bulk of the information into a single value to express the data in a simplified and logical form and demonstrate annual cycles, spatial and temporal variation and trends in water quality at low concentrations (Shweta et al, 2013). An index is most useful for comparative purposes and for general questions and

[1]Alexandru Ioan Cuza University, Faculty of Geography and Geology, Iaşi, Romania
e-mail: madalina.paiu@yahoo.com
[2] Alexandru Ioan Cuza University, Faculty of Geography and Geology, Iași, Romania
e-mail: iulianab2001@gmail.com

less suited to specific questions. Site-specific decisions should be based on an analysis of the original water quality data. The index is a useful tool for communicating water quality information to the large public and to legislative decision makers; it is not a complex predictive model for technical and scientific application. (Hallock, 2002; Yogendra, 2008). Weight arithmetic water index method classified the water quality according to the degree of purity, using the most commonly measured water quality variables.

Lakes are know to be ecological barometers of the health of settlements, influencing the life of the nearby residents. The environmental condition of any lake or stream river depend on nature of water resources and the exposure to various environmental factors such natural processes (precipitation inputs, erosion, weathering of parent material) as well as anthropogenic influences (urban, industrial, agriculture activities). In recent decades the agricultural activities, sewage runoff and population growth have increase the level of nutrients thus favoring advanced eutrophication. In those lake that are drinking water supply two main causes have been identified: pollutants flux entering from fixed point sourses or from non-point sources, mainly from agriculture runoff and human waste waters.

This study reveals how these wide variations in different parameters can be reduced to a single number when reported with the help of WQI, thereby making it quite convenient to comment on the overall quality of the water sample from its pollution point of view. (Kankal et al, 2012, S.P. Gorde et al, 2013)

The present study assessed the surface water quality for two rivers and three catchments based on the Water Quality Index. The catchments studied in this paper are Pârcovaci (Bahlui HB), Chirița (Prut HB) from Iași county and Dracșani (Sitna HB) from BotoșaniCounty.

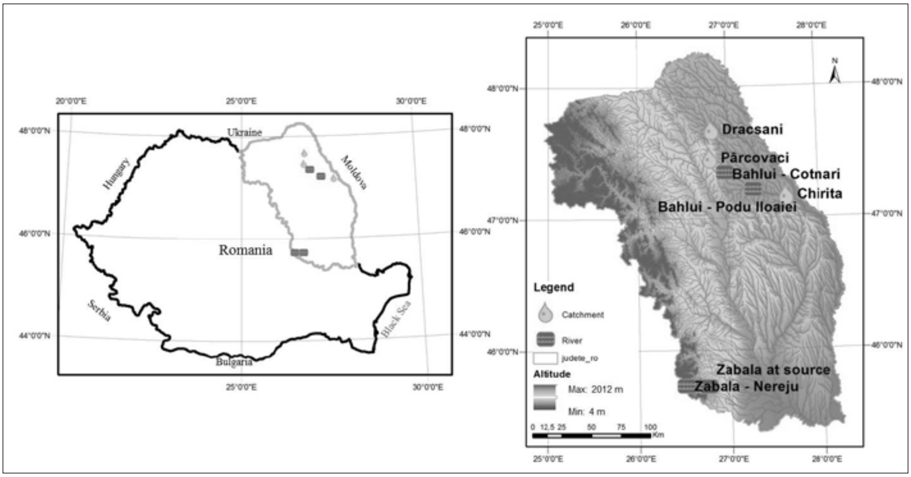

Fig. 1 Sampling points location in Romania

2. MATERIALS AND METHODS

Surface water samples were collected from two sampling locations for Bahlui and Zăbala rivers and one sampling point for each of the three studied lakes. (Fig. 1) Samples were collected once a month during the year 2012 in polythene bottles and analyzed for several water quality parameters. The two studied rivers, Zăbala and Bahlui have different backgrounds, Zăbala being a mountain river with little human impact whereas Bahlui is a hillside river with dense settlements that heavily influences the water quality. Chirița catchment is an artificial water body that is used in supplying drinking water to Iași city. Pârcovaci and Dracșani catchments are both natural lakes with no human involvement in their appearance. All three studied lakes are situated in Eastern part of Romania, Moldova, in an intense cultivated hillside area.

Weight arithmetic water index method classified the water quality according to the degree of purity, using the most commonly measured water quality variables, such as temperature, pH, turbidity, faecal coliform, dissolved oxygen, biochemical oxygen demand, total phosphates, nitrates and total solids. The method has been widely used by various researches (Roşu et al 2013, I. Piştea et al 2013, Iticescu et al 2013). The water quality data are recorded and transferred to a weighting curve chart, where a numerical value of Qi is obtained (Breabăn et al, 2012) by using the following equation:

$$WQI = \sum_{i=1}^{n} QiWi$$

where,

Qi = sub-index for ith water quality parameter;

Wi = weight associated with ith water quality parameter;

n = number of water quality parameters

The calculation of Water Quality Index (WQI) was carried out using a JavaScript webmaster software developed by Brian Oram, PG B.F. Environmental, (http://www.waterresearch.net/watrqualindex/index.htm,2013) and the results obtained for each sample tested is reported. Water quality index is calculated to determine the suitability of water for different purposes. (Kankal et al, 2012).

Table 1. Status of water quality according to the WQI values (House and Ellis, 1987)

WQI Value	Status
91 - 100	Excellent water quality
71 - 90	Good water quality
51 - 70	Medium water quality
26 - 50	Bad water quality
0 - 25	Very bad water quality

In general, samples scoring 71 and above met expectations for water quality and are of lowest concern, scores 51 to 71 indicate marginal concern, and water quality at stations with scores below 50 did not meet expectations and are of highest concern. (Table 1)

In situ measurement was used to determine unstable parameters such as: pH, electrical conductivity, temperature and total dissolve solids using Multi 350i/SET WTW multiparameter instrument, while the chemical parameter were analysed in the laboratory using standard methods. (Breabăn et al, 2012)

3. RESULTS AND DISCUSSIONS

The monitored parameters include a great variety of physico-chemical and biological/ organic parameters, excepting the microbiologic parameter – Total Coliforms, because it is monitored in the sections where the water is destined for the potable use: dissolved oxygen, BOD_5, pH, nitrates, phosphates, turbidity. (Oişte A. M., 2012)

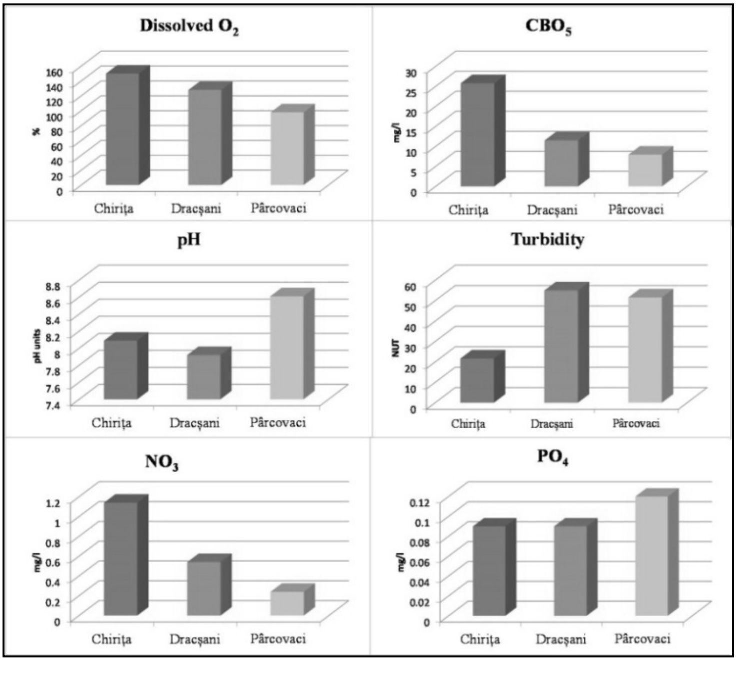

Fig. 2. Annual average concentration for each parameter in WQI – Catchments

In figure 2 were represented the average concentration for each of the 6 parameters that compute the WQI by comparing the three studied catchments. From all catchments, Chiriţa is the one with the highest concentrations of nitrates, BOD_5 and dissolved O_2 while Pârcovaci has the highest values for phosphates and pH. The main source responsible for the increase concentrations of nitrate and phosphates is the rainwater that percolates previously fertilized farmland, the polluted waters flow into the rivers and lakes increasing the concentration for certain parameters.

The DO levels in catchments vary according to their trophic levels, the depletion of DO in water probably is the due to water pollution. It fluctuate seasonally, daily and with variation in water temperature mainly due to consumption of DO owing to respiration by aquatic animals, decomposition of organic matter, and various chemical reactions.

Regarding the rivers (Fig. 3) has been noticed that Bahlui present the highest concentrations of BOD_5, nitrates, phosphates, turbidity and the lowest of dissolved oxygen. This situation can be attributed to the different ways of land using, mostly agricultural for Bahlui river basin compared with Zăbala river basin where the land is mostly occupied by forest with little diffuse or punctual pollution sources.

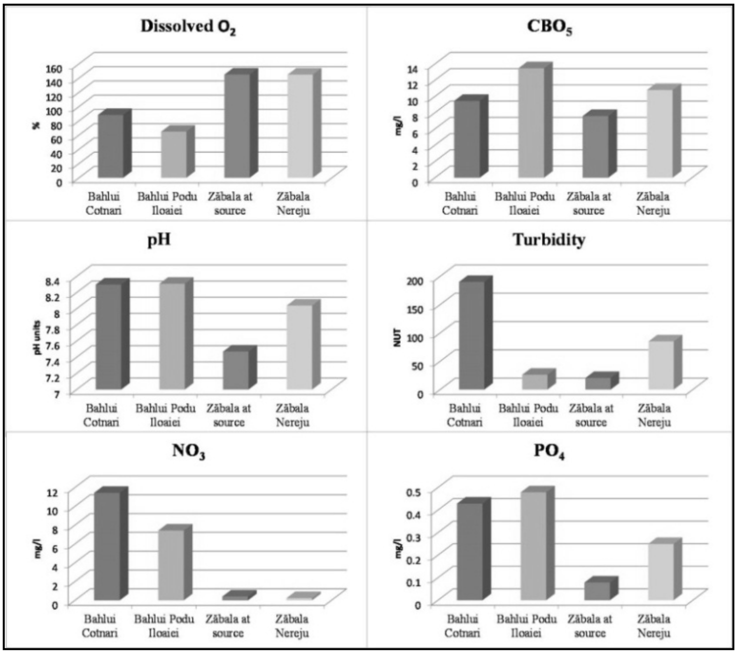

Fig. 3. Annual average concentration for each parameter in WQI – Rivers

The altitudinal and climatic dispositions are responsible for the differentiation in the dissolved oxygen level, one being in a predominantly mountainous area while the other is in a hillside region.

Water Quality final Index falls into medium and good class, with variable values for each river and catchment. (Fig. 4 and Fig. 5). Comparing the catchments, Pârcovaci has the highest WQI value with an annual average of 79.5, follwed by Dracșani with a value of 73.25 placing both water bodies in the good water quality class. Chirița catchment has one of the lowest values of WQI, an average of 64.25 being classified as a waterbody with medium water quality. The low value of WQI should be worrying because the water is being used in supplying Iași Municipality with drinking water.

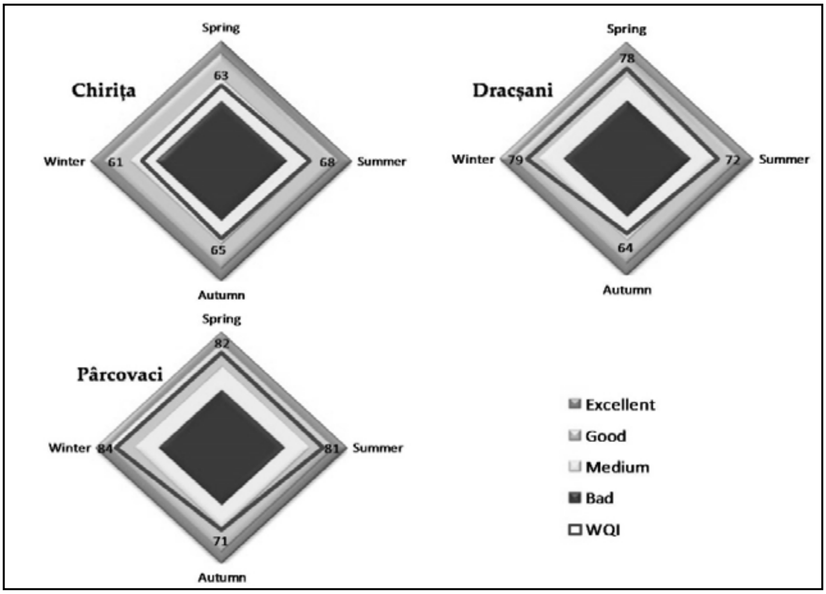

Fig. 4. Seasonal WQI for Chirița, Dracșani and Pârcovaci catchments

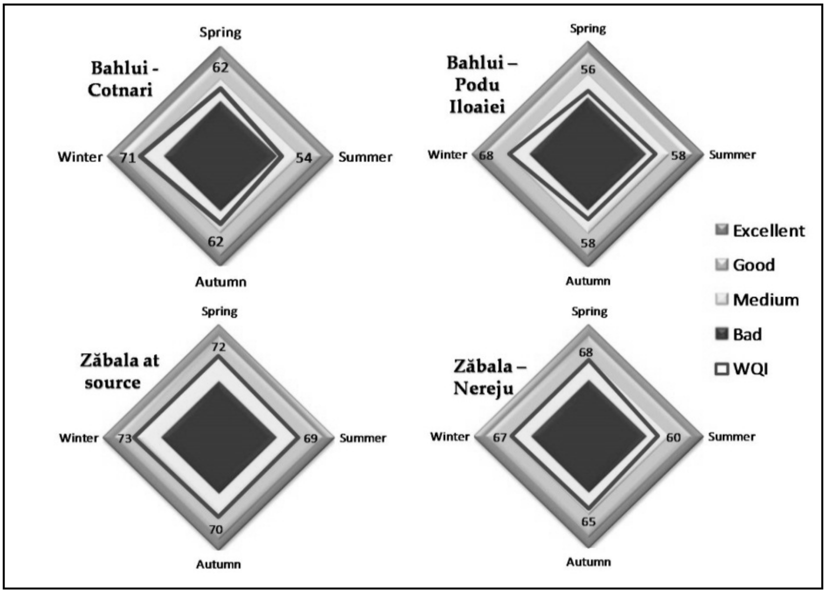

Fig. 5. Seasonal WQI for Bahlui and Zăbala rivers

In the case of Bahlui and Zăbala rivers, the WQI falls into the medium water quality class, except for the Zăbala at source sampling point that scored an annual average WQI of 71 placing it in the good water quality class. The low value of 60, the average annual WQI for Bahlui at Podu Iloaiei, is due to anthropogenic influences as the sampling point is situated downstream of Podu Iloaiei City. In fact all three points which were ranked as with medium water quality are located near human sttlements.

The relevance of the WQI is given by the importance as instrument in the authorities' management plans to improve water quality in the area, including the citizens' information concerning the water resources quality in their living area. (Oişte A. M., 2012)

4. CONCLUSIONS

Based on the use of WQI, this study presents the assessment of water quality from different hydrographical basins as well some catchments. The general conclusion is that some indicators put into evidence mostly organic pollution.

One of the advantages of using a water quality index in assessing the overall quality of the water is that it sums up numerous data in a single value in an impartial, rapid and logical way, it evaluates different areas and detects changes in water quality and also an index value can relate to a potential use of that source of water.

Even though WQI facilitates communication with people who do not have expert knowledge regarding water quality, when calculating the WQI, a great amount of data is handled and a loss of data can occur easily. A WQI means not having to deal with unpredictability and subjectivity present in complex environmental issues.

A good WQI at a specific sampling site does not necessarily mean that water quality was always good. A good score should, however, suggest that a poor water quality was not chronic during the period included in the index.

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