WATER QUALITY ASSESSMENT OF THE NADAS RIVER (ROMANIA) IN TERMS OF NSF WATER QUALITY INDEX

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Abstract

Water quality of Nadas River, a tributary of Somes Mic Watershed (Romania) was evaluated with the NFS Water Quality Index (NFS WQI) method. Water Quality Index (WQI) is a dimensionless number that combines multiple water-quality factors into a single number by normalizing values to subjective rating curves. The method consists in the computation of the Water Quality Index on the basis of the physical-chemical and biological quality. Changes in water temperature, pH, dissolved oxygen level, biochemical oxygen demand, total phosphorus level, nitrates, and suspended solids were used for the calculation of the index.

The study on WQI of Nadas River is based on the parameters that were registered at the Nadas River monitoring stations of the Somes–Tisa Water Directorate, over the period: 2008-2012. Using the listed data the quality of water study was concluded. There have been obtained the following range of WQI: Nadas River Radaia sector 82-87, Nadas River upstream confluence with Somes Mic River sector 71-83, indicating a good water quality. In case of Popesti River sector WQI ranged from 62 to 67 indicating a medium water quality.

The present study highlights the importance of applying a water quality index that reflects the collective influence of all different criteria responsible for water pollution of any river body and which allows interpretation of data based on monitoring.

Key words: physical-chemical parameter, index, value, water quality, Nadas River.

INTRODUCTION

Water Quality Index (WQI), is a dimensionless number that combines multiple water-quality factors into a single number by normalizing values to subjective rating curves. It is a widely used communication tool which summarizes water quality data in an effective and understandable way for to the general public.

Numerous water quality indices have been developed, all over the world, as a convenient means of summarizing water quality data, each using various groups of analytes, which can promptly and efficiently easily assess the water quality within a particular area (House, 1989; Bharti, Katyal, 2011). Some examples are in USA, the National Sanitation Foundation's Water Quality Index (NSF-WQI), British Columbia Water Quality Index, Oregon Water Quality Index, Florida Stream Water Quality Index, in Canada, the Canadian Council of Ministers of the Environment's Water

Quality Index (CCME-WQI), and so on. These indices are based on the comparison of the water quality parameters to regulatory standards and give a single value to the water quality of a source (Khan et al., 2003; Abbasi, 2002). The major differences in various WQIs are based on the mannerism of statistical integration and interpretation of parameter values (Lumb et al., 2011).

In general water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of water body with a single number. That number is placed on a relative scale to justify the water quality in categories ranging from very bad to excellent.

One of these indices is the NSF Water Quality Index, a standardized method for comparing the water quality of various water bodies, developed in 1970 by the National Sanitation Foundation (Brown R.M. et al., 1970). Nine water quality parameters were selected based on Delphi method to include in the index. These parameters are as dissolved oxygen, fecal coliforms, pH, biochemical oxygen demand, temperature changes, total phosphates, nitrates, turbidity and total solids. Some parameters were judged more important than others, so a weighted mean was used to combine the values (Table 1).

Table 1

Water quality parameters and their weight
(Source: http://www.water-research.net/watrqualindex/index.htm)

Parameter	Weight
Dissolved oxygen	0.17
Fecal coliform	0.16
pH	0.11
Biochemical oxygen demand	0.11
Temperature change	0.10
Total phosphate	0.10
Nitrates	0.10
Turbidity	0.08
Total solids	0.07

When test results from fewer than all nine measurements are available, the relative weights for each factor are preserved and the total scaled so that the range remains 0 to 100.

The values obtained for the Water Quality Index are divided into five intervals that render that surface water quality and field of use (House, Ellis, 1987):

- 10 ÷ 25% - Very bad (water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels)
- 25 ÷ 50% - Bad (water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels)

- 50 ÷ 70% - Medium (water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels)
- 70 ÷ 90% - Good (water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels
- 90 ÷ 100% - Excellent (water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels).

In other words, NSFWQI summarizes large amounts of water quality data into simple terms for reporting to management and the public in a consistent manner.

Since 2000 there are two online calculators for calculating the index: WQHYDRO (Aroner, 2002) and Monitoring the Quality of Surface waters, Brian Oram, according to Field Manual for Water Quality Monitoring (http://www.water-research.net/watrqualindex/index.htm).

Some of the advantages of using an index to assess the quality of surface waters include:

- its ability to represent measurements of many water quality parameters in a single number;
- its ability to combine numerous parameters with different measurement units;
- its effectiveness as a communication tool.

MATERIAL AND METHOD

The Nadas River is a tributary of the Somes Mic River in Romania. The main data is: area, 372 km^2; length, 44 km; average altitude, 505 m; average flow, 1.6 m^3/s. The main tributaries from source to mouth are: Leghia, Inucu, Macau, Garbau, Mera, Suceag and Popesti.

US National Sanitation Foundation's Water Quality Index was the WQI model applied for the assessment of water quality of Nadas River lower course. The WQI of Nadas River was calculated using the following parameters: pH (pH units), total solids (mg L^{-1}), dissolved oxygen (mg L^{-1}), biochemical oxygen demand (mg L^{-1}), nitrates (mg L^{-1}) and total phosphorus (mg L^{-1}). For the monitoring of water quality in Nadas River lower course, 3 sampling stations were selected: S1-Nadas River at Radaia, S2-Popesti River upstream confluence with Nadas River and S3 – Nadas River upstream confluence with Somes Mic River. The locations of these sampling stations are shown in Fig. 1.

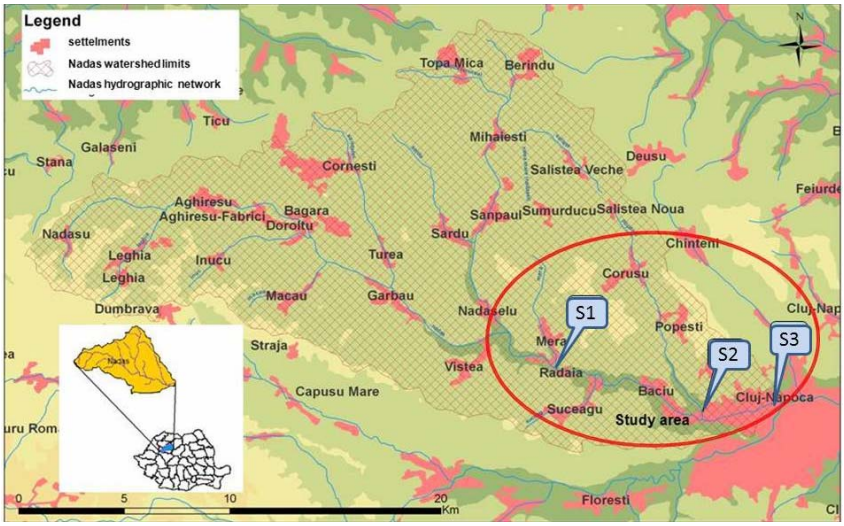

Fig. 1. Map of the study area

The water quality index of individual parameter was calculated from water quality index calculator used by Environmental Engineering and Earth Sciences, Center of Environmental Quality, Wilkes University.

RESULTS AND DISCUSSION

Nadas basin is characterized by a mainly agricultural land use. In the study area, industrial activities that generate pollution are concentrated largely in the areas of exploitation of mineral resources (Nadas valley – Aghireş) and Popeşti valley, a tributary of Nadas (area of concentration of poultry). Diffuse pollution might occur by domestic waste water and agricultural landscape drainage water causing an increase of phosphates and organic matter in the water.

There were used data for the period 2008-2012 (data provided by the Somes–Tisa Water Directorate) (Tables 2-4).

Table 2

Physical-chemical characteristics of the water from Nadas River at Radaia monitoring station (Source: Somes–Tisa Water Directorate)

Parameter	Annual Mean ± standard deviation				
	2008	2009	2010	2011	2012
Water temperature (°C)	11.4±5.9	9.6±6.5	9.13±5.45	9.95±7.84	11.98±5.91
pH (pH unit)	7.9±0.5	7.9±0.16	7.93±0.31	8.01±0.1	7.97±0.06
DO (mg L^{-1})	9.43±2.19	8.64±1.49	9.6±2.14	10.71±2.23	9.73±2.18
BOD5 (mg L^{-1})	4.7±4.8	4.63±1.81	4.21±1.62	3.9±0.93	6.99±2.07
Nitrates (mg L^{-1})	1.91±0.96	1.80±1.075	1.80±0.33	1.59±0.61	1.19±0.52
Total phosphorus (mg L^{-1})	0.13±0.12	0.19±0.132	0.13±0.08	0.17±0.05	0.2±0.09
Suspended solids (mg L^{-1})	193.3±320.55	108.8±182.27	-	32.08±27.61	24.80±35.84

Table 3

Physical-chemical characteristics of the water from Popesti River upstream confluence with Nadas River monitoring station (Source: Somes–Tisa Water Directorate)

Parameter	Annual Mean ± standard deviation				
	2008	2009	2010	2011	2012
Water temperature (°C)	11.6±7.69	10.2±6.05	9.3±5.85	10.69±9.64	12.08±7.29
pH (pH unit)	7.8±0.19	7.9±0.14	7.97±0.05	7.75±0.17	7.88±0.12
DO (mg L^{-1})	6.82±3.37	5.80±3.31	7.54±2.33	7.73±3.17	8.69±3.34
BOD5 (mg L^{-1})	11.32±13.49	7.82±4.80	7.71±3.65	33.10±54.14	11.92±6.7
Nitrates (mg L^{-1})	0.85±0.79	0.74±0.66	1.64±2.41	0.65±0.63	1.29±1.08
Total phosphorus (mg L^{-1})	2.23±3.52	1.36±1.2	0.89±0.79	2.12±1.74	0.91±0.67
Suspended solids (mg L^{-1})	188.3±275.02	77.8±133.88	-	74.67±107.15	12.88±11.98

Table 4

Physical-chemical characteristics of the water from Nadas River upstream confluence with Somes Mic River monitoring station (Source: Somes–Tisa Water Directorate)

Parameter	Annual Mean ± standard deviation				
	2008	2009	2010	2011	2012
Water temperature (°C)	11.6±7.71	10.6±6.54	9.77±5.94	11.22±8.83	12.0±6.13
pH (pH unit)	7.9±0.11	8.0±0.16	8.01±0.19	8.02±0.1	7.88±0.15
DO (mg L^{-1})	8.86±2.31	7.07±2.36	8.15±1.90	9.97±2.10	9.63±2.64
BOD5 (mg L^{-1})	6.09±5.97	6.79±3.62	6.96±3.16	5.4±1.54	9.37±3.02
Nitrates (mg L^{-1})	2.243±0.614	1.586±0.785	2.03±0.61	0.65±0.63	2.27±0.47
Total phosphorus (mg L^{-1})	0.184±0.099	0.487±0.812	0.31±0.17	2.12±1.74	3.38±0.16
Suspended solids (mg L^{-1})	151.3±310.32	96.3±133.48	-	88.60±88.51	156.55±188.8

The calculated factors, resulting WQI and the categorization are listed in Table 5.

Table 5

The calculated sub-index values, WQI and quality

Year	Station no	Sub-index values						WQI	Quality
		pH	DO	BOD5	Nitrates	Total P	TDS		
2008	S1	87	92	57	95	95	73	84	Good
	S2	90	62	29	96	26	74	62	Medium
	S3	87	87	50	94	93	79	82	Good
2009	S1	87	82	58	95	92	83	82	Good
	S2	87	46	43	96	33	85	62	Medium
	S3	84	64	47	95	61	84	71	Good
2010	S1	86	90	60	95	95	-	85	Good
	S2	85	68	43	95	44	-	67	Medium
	S3	84	78	46	95	80	-	76	Good
2011	S1	84	98	62	95	93	85	87	Good
	S2	91	75	5	96	26	86	63	Medium
	S3	83	96	54	95	78	84	83	Good
2012	S1	85	95	46	96	92	84	84	Good
	S2	88	88	28	96	28	78	69	Medium
	S3	88	95	37	95	73	78	79	Good

In the NSFWQI model, the water quality data for all the sampling stations are categorized as Medium (S2) to Good (S1 and S3) (Table 5). Biochemical oxygen demand, Total phosphorus, Total solids and Dissolved

oxygen are the main parameters which lower the overall WQI value in all stations. When the calculated index values and water quality data are compared, the index values are rational at all monitoring stations. Based on water quality index, the water of Popesti River can be classified as class III and the water quality is medium. For public water supply system, this water requires necessary treatment.

Summarizing the results, there have been obtained the following range of WQI: Nadas River Radaia sector 82-87, Nadas River upstream confluence with Somes Mic River 71-83, indicating a good water quality. In case of Popesti River sector, WQI ranged from 62 to 67 indicating a medium water quality.

CONCLUSIONS

Water Quality Index becomes an important parameter for the assessment and management of surface water.

The NSFWQI was developed with the intent of providing a tool for simplifying the reporting of water quality data. It is a tool that provides meaningful summaries of water quality data that are useful to technical and policy individuals as well as the general public interested in water quality results. As a summary tool, it provides a broad overview of water quality data and is not intended to be a substitute for detailed analysis of water quality data.

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