RESEARCH OF SURFACE WATERS QUALITY IN HILLY AREAS WITH MODEL "WAQ"

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Abstract: *Water quality modelling with "WaQ" wants to improve current systems for monitoring, the model allows establishing the source of pollutants and limits for discharges that lead to poor quality water, as well as the basic or additional measures necessary to achieve environmental objectives under Framework Directive 2000/60. Analysing the data output of the model "WaQ" for the Bahlui catchment it has been found that impairment of good water, especially regarding nutrients as required by the directive is given by agricultural work practices, this fact indicating agriculture as one of the main sources of diffuse pollution of surface water, including barrier lakes. As a result of modelling with "WaQ" for Bahlui catchment, the forecast made in the perspective of 2021, was found an increase in total nitrogen and total phosphorus imissions compared to 2012, fact caused by increasing agricultural areas. On the other hand, only for the sub-basin Razboieni-upstream Podu Iloaiei was determined a decrease in load with total nitrogen and total phosphorus in 2021, which resulted an improvement of the ecological potential for the barrier lake Podu Iloaiei.*

Keywords: *nutrients, quality status, pollution sources.*

1. Introduction

Water Framework Directive is the main part of water legislation and has been adopted by the European Commission to ensure sustainable management for all water bodies from European Union [11]. The result of implementing sustainable management of the water sector is to create a healthy and unpolluted aquatic ecosystem, an objective that can be achieved by reporting to ecological, economic and social conditions.

Water Framework Directive requires considering only significant pressures, more exactly the pressures that produce a significant impact on water quality, such as those that result is not achieving the environmental objectives for water bodies studied [7].

As result of human pressures, such as urban agglomerations, industrial activities, agricultural activities or morphological alterations, the status of water bodies has been affected. This means it was restructured through the loss of biodiversity and aquatic habitats on the one hand, and the changing water quality as a resource on the other.

In this regard, Water Framework Directive introduces a new concept on the water bodies status represented by the ecological status (whose evaluation is done by integrating the biological elements with physicochemical elements and specific pollutants) and by chemical status (whose assessment is based on the impact of priority hazardous substances represented by heavy metal ions and organic micro pollutants).

2. Additions

Bahlui catchment is located in the north-eastern Romania, overlay an area with a central-north-eastern position within Moldova Plateau and integrating under hydrological rapport in the Middle Prut River system. Bahlui River is a right tributary of Jijia River in the common meadow of Prut River. In administrative and territorial terms, Bahlui catchment is integrated with Iasi County, excepting the extreme north-west [3].

In selecting a quality mathematical model to analyse a problem either present or future pollution, it is necessary to consider not only all the interdependencies and influence factors, but also the purpose for which it will be used.

Considering that the problem of water quality in the Bahlui catchment is the nutrient pollution, for study was chosen a mathematical model “WaQ” which wants to make a forecast water quality by modeling two parameters: total nitrogen (Nt) and total phosphorus (Pt). The objectives of this model are part of the main objective of the Water Framework Directive 2000/60/EC.

By this modelling programme can be developed scenarios which provide a series of measures to reduce pollution. There are base scenarios that require the implementation of all the measures from European Directives about water quality and optimal scenarios resulted when measures implemented by base scenarios will not lead to achieving the good water status. For both apply load balance equation taking into account both sources of pollution: punctual and diffuse [8].

Table 1 presents specific nutrient loads coming from punctual and diffuse sources.

Table 1. Specific nutrient loads coming from punctual and diffuse sources [9]

Number	Pollution sources	Type of pollution
1	Emissions from localities	diffuse
2	Landfills leaks derived from animals	diffuse
3	Effluents from industry, livestock farms, agglomerations	punctual
4	Farmland leaks where fertilizers are applied	diffuse
5	Leaks on land with perennial crop where fertilizers are applied	diffuse
6	Atmospheric deposition	diffuse
7	Leaked of natural land occupied by forests, grass, etc.	diffuse
8	Contribution of wetlands	diffuse

“WaQ” initially requires a topological modelling of studied catchment, assuming this division into sub-basins considering the closing section, the section of water quality monitoring, as shown in Fig.1. This modelling are the following: sub-basins of type 1 and 3 start at the source of the river and have the closing sections the first section of water quality monitoring (Section A, Section B), sub-basin type 2 is between two successive sections of water quality monitoring (sections A-B) and sub-basin type 4 is between two successive sections of water quality monitoring (sections B) and includes a major tributary [8].

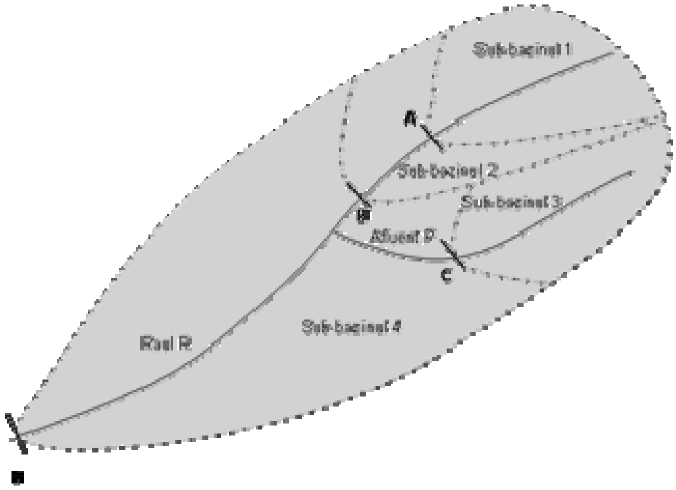

Fig.1. Topological modelling of catchment [8]

The model is applied to each sub-basin and the data is obtained in upstream sub-basin become inputs to the next downstream sub-basin.

Following topological modelling with "WaQ" of Bahlui catchment result 10 sub-basins of type 2, 3 and 4, as defined above. This boundary can be highlighted in Table 2, and will also include the barrier lakes.

Table 2. Delimitation of Bahlui catchment and setting for each sub-basin the barrier lakes

Bahlui, sub-basin streams-Vama with Tabla type 3, section 1	-
Bahlui, sub-basin Vama with Tabla-upstream Harlau type 2, section 2	Barrier lake Parcovaci
Bahlui, sub-basin upstream Harlau-downstream Harlau type 2, section 3	-
Bahlui, sub-basin downstream Harlau-downstream Belcesti type 2, section 4	Barrier lake Tansa-Belcesti
Bahlui, sub-basin downstream Belcesti-Podu Iloaiei type 4, section 5	Barrier lake Plopi
Bahlui, sub-basin Podu Iloaiei-Holboca type 4, section 6	Barrier lakes Cucuteni, Rediu, Aroneanu, Ciric(3), Chirita
Bahluet, sub-basin streams-upstream Targu Frumos type 3, section 1	-
Bahluet, sub-basin upstream Targu Frumos-Razboieni type 2, section 2	-
Bahluet, sub-basin Razboieni-upstream Podu Iloaiei type 2, section 2	Barrier lakes Sarca, Podu Iloaiei
Nicolina, sub-basin streams–upstream confluence Bahlui type 3, section 1	Barrier lakes Ciurbesti, Ezareni

"WaQ" model equation is:

$Im_{av.} = (1- C_L) * [Im_{am.} + Em_{pct.} * (1-C_{red.p}) + (1-C_R) * (Em_{dif} *(1-C_{red.dif}) + Em_{fond})$ (1) [8]

Where:

$Im_{av.}$ = Imissions measured in river section downstream monitoring;

Im_{am}. = Imissions measured in river section upstream monitoring;

$Em_{pct.}$ = Emissions from sources of punctual pollution in analyzed sub-basin;

$Em_{dif.}$ = Emissions from sources of diffuse pollution in analyzed sub-basin;
Em_{fond} = Emissions from natural background measured in analyzed sub-basin;
C_L = Pollutant Reduction Factor in lakes;
C_R = Pollutant Reduction Factor in the interfluvial and small rivers;
$C_{red.p}$ = Pollutant Reduction Factor from punctual sources required to develop optimal scenario;
$C_{red.dif}$ = Pollutant Reduction Factor from diffuse sources required to develop optimal scenario.

Determining the specific parameters of the model, CR and CL is based on data for the reference year. Because by using this model it is desired a forecast for water quality in 2021, are introduced the first estimates data about the evolution of agricultural area, agglomerations, areas under perennial crops, forests and wetlands, and assessing charging chemical nitrogen and phosphorus nutrients [8].

In this model calibration was performed using as the base year 2012 and forecast water quality was conducted for 2021 by tracking the time variation of the two indicators of total nitrogen and total phosphorus.

In assessing current conditions and the forecast made for 2021 were used on the one hand annual average concentration of total nitrogen and total phosphorus corresponding annual average flow (on the year 2012), and on the other hand annual average concentration of flow with their corresponding probability of exceeding 95 % [8].

Following assessments surfaces on each sub-basin in part, based on data obtained from Water Basinal Administration Prut-Barlad, was found that in the Bahlui catchment the largest share is represented by farmland, followed by forests and perennial crops, while the lowest share is wetlands.

Analysis emissions of total nitrogen and total phosphorus achieved in 2012 (data obtained from Water Basinal Administration Prut-Barlad), in each sub-basin and each type of source, has revealed that emissions from natural background sources (atmospheric deposition, perennial crops, forests) and diffuse sources (agricultural land) had the largest share, while punctual sources are less relevant.

After applying the model, the forecast made in anticipation of 2021 showed for the most part an increase imisssions of total nitrogen and total phosphorus compared with those measured in 2012.

The exception was observed for sub-basins streams-Razboieni and Razboieni–upstream Podu Iloaiei where was checked a decreased in the load of total nitrogen and total phosphorus, as was shown in Table 3.

Table 3. Imission variation of total nitrogen and total phosphorus in the Bahlui River

Sub-basin	**Imission of total nitrogen (t/an)**		**Imission of total phosphorus (t/an)**	
	2012	**2021**	**2012**	**2021**
Bahlui, sub-basin streams-Vama with Tabla type 3, section 1	0,72	1,16	0,10	0,12
Bahlui, sub-basin Vama with Tabla-upstream Harlau type 2, section 2	7,50	8,18	0,05	1,20
Bahlui, sub-basin upstream Harlau-downstream Harlau type 2, section 3	52,00	56,00	4,50	4,50
Bahlui, sub-basin downstream Harlau-downstream Belcesti type 2, section 4	96,50	110,00	7,60	8,60

Bahlui, sub-basin downstream Belcesti-Podu Iloaiei type 4, section 5	53,91	55,00	14,27	16,00
Bahlui, sub-basin Podu Iloaiei-Holboca type 4, section 6	384,71	490,00	126	170,00
Bahluet, sub-basin stream- Razboieni	46,00	29,00	6,32	4,50
Bahluet, sub-basin Razboieni-upstream Podu Iloaiei type 2, section 2	13,50	8,60	3,80	2,85
Nicolina, sub-basin streams–upstream confluence Bahlui type 3, section 1	9,91	10,80	0,84	0,90

Analysing the total nitrogen and total phosphorus emissions forecasted for 2021, as shown in Table 4, it was found only for Bahlui, sub-basin streams-Vama with Tabla and Bahlui, sub-basin Vama with Tabla-upstream Harlau a very small increase of those from punctual sources and in all other sub-basins a decrease. The emissions of total nitrogen and total phosphorus from diffuse sources were recorded increases for all sub-basins analysed because it was assumed increasing the area cultivated. On emissions from natural background was observed a slight variation of total nitrogen and total phosphorus.

Table 4. Forecast total emissions of total nitrogen and total phosphorus in the Bahlui River

Sub-basin	**Total nitrogen emissions in 2021 (t/an)**			**Total phosphorus emissions in 2021 (t/an)**		
	Diffuse sources	**Natural background sources**	**Point sources**	**Diffuse sources**	**Natural background sources**	**Point sources**
Bahlui, sub-basin streams-Vama with Tabla type 3, section 1	0	23,60	0,40	0	2,32	0,03
Bahlui, sub-basin Vama with Tabla-upstream Harlau type 2, section 2	24,90	73,00	0,40	3,40	6,95	0,03
Bahlui, sub-basin upstream Harlau-downstream Harlau type 2, section 3	39,00	8,90	0	6,00	0,80	0
Bahlui, sub-basin downstream Harlau-downstream Belcesti type 2, section 4	194,00	160,00	0,40	22,00	15,35	0,03
Bahlui, sub-basin downstream Belcesti-Podu Iloaiei type 4, section 5	250,00	267,00	0,40	22,00	25,80	0,03

Bahlui, sub-basin Podu Iloaiei-Holboca type 4, section 6	985,00	425,00	0,40	120,00	42,60	0,03
Bahluet, sub-basin stream - Razboieni	126,00	70,20	0,40	10,10	7,79	0,03
Bahluet, sub-basin Razboieni-upstream Podu Iloaiei type 2, section 2	187,00	185,80	0,40	13,20	18,75	0,03
Nicolina, sub-basin streams–upstream confluence Bahlui type 3, section 1	150,10	127,00	0,40	15,00	12,18	0,03

By applying topological modelling of the sub-basin Razboieni-upstream Podu Iloaiei result the barrier lake Podu Iloaiei (Fig.2), the most eutrophic lake from the Bahlui catchment. The barrier lake Podu Iloaiei is located on the Bahluet River about 25 km upstream of its confluence with the stream Bahlui. From the administrative point of view, the barrier lake Podu Iloaiei is located about 400 m upstream of Podu Iloaiei town, Iasi County. The barrier lake Podu Iloaiei was designed with complex functions, between the most important is the flood defences of social and economic objectives downstream and to mitigate flood waves produced on Bahluet River [10].

Fig.2. The barrier lake Podu Iloaiei - Water Basinal Administration Prut-Barlad

Table 5 shows the ecological potential of the barrier lake Podu Iloaiei during 2012-2015 as a result of biological elements, physicochemical general elements and specific pollutants monitored.

Table 5. Evolution of ecological potential of the barrier lake Podu Iloaiei [6]

Ecological potential of the water body in terms of:	**2012**	**2013**	**2014**	**2015**
Biological elements monitored	-	Moderate	Good	-
General physicochemical elements	-	Moderate	Moderate	Moderate
Specific pollutants	-	Good	Maxim	-
Integrated assessment of ecological potential of the water body	-	Moderate	Moderate	-
Elements that led to attainment of the quality objective	-	Phytobenthos, oxygenation conditions, acidification and nutrient status	Status of acidification, oxygen, nutrients	-
Chemical status	-	Good	Good	-

As discussed above, after modelling with "WaQ", forecast made in anticipation of 2021 revealed to sub-basin Razboieni-upstream Podu Iloaiei a decrease in total nitrogen and total phosphorus loading. The quantities of nutrients are transported in the barrier lake Podu Iloaiei by river network on one side, or by processes flow from slopes or by erosion processes on the other hand. Normally the nutrients are quickly consumed by phytoplankton and phytobenthos, but even so sometimes they persist, this fact highlight the continuous nature of diffuse pollution.

In terms of quality, physicochemical, biological, microbiological characteristics of barrier lake Podu Iloaiei depend on the characteristics of the sub-basin Razboieni-upstream Podu Iloaiei, mostly likely to diffuse pollution with nitrogen and phosphorus nutrients coming from agro work practices, but at punctual source pollution from effluent agglomerations. Thus, if the results from the model "WaQ" for 2021 showed a decrease in load of total nitrogen and total phosphorus of this sub-basin, this also confirms an improvement of the ecological potential for the barrier lake Podu Iloaiei.

3. Conclusions

Analyzing the data output of the model "WaQ" for the Bahlui catchment, overall, was found an increase in total nitrogen and total phosphorus imissions in 2021 compared to 2012, fact caused by increasing agricultural areas and decrease in forest areas. Applicability of the model "WaQ" is a tool to assess the impact of basic measures, as well as a tool for selecting priorities in taking additional measures to reduce pollution. Based on results of modelling application can select more precisely significant pressures and determine sectors/bodies at risk.

On the other hand, for the sub-basin Razboieni-upstream Podu Iloaiei was determined a decrease in load with total nitrogen and total phosphorus in 2021, which resulted an improvement of the ecological potential for the barrier lake Podu Iloaiei.

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