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Determining the vulnerable and potentially vulnerable areas to nitrate pollution in the Banat Hydrographical area

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Abstract: This paper aims at presenting the methodology of determining the vulnerable and potentially vulnerable areas to nitrate pollution. This methodology uses touristic methods and information taken from pedological studies at a high scale. As a result, the first method uses indeces regarding the natural vulnerability for the pollution of nitrate waters. They are: vulnerability through percolation index and vulnerability through drainage index. The second method classifies agricultural lands into nitrogen vulnerable areas taking into account the soil's texture, the soils' permeability, the land's slope, the erosion danger at the land's surface and the land's uniformity.
Keywords: vulnerable areas, pollution, nitrates.

1. INTRODUCTION

Within the European Union, legislative instruments to protect and sustainably manage water resources were promoted.

Thus, Framework Directive 2000/60 defines water as a heritage that must be protected, treated and preserved as such.

This directive sets up the necessary framework for the water sustainable management, i.e. the quantitative and qualitative management of waters until 2015.

The Framework Directive is implemented through the Management Plan of the Danube Hydrographic Basin, which is made up of two plans: the general plan and the regional management plans of the Danube countries.

The management plan of the hydrographic basin presents the identification and mapping of the protected areas in which the following are included:

- Protection areas for the water catchments designed for potabilisation;
- Areas for the protection of aquatic species that are important from an economic point of view;
- Areas for the protection of the habitats or species where water is an important factor;
- Nitrate vulnerable zones;
- Natural areas created for bathing.

2. MATERIAL AND METHOD

The methodology to delimit the vulnerable areas consisted of the analysis of each subsystem (soil, climate, water, nitrate sources resulted from agricultural activities) from the point of view of producing and conveying the nitrates from agricultural sources towards water surfaces. The developed methodology uses two ways for vulnerability assessment: interpreting the natural factors which influence the nitrate conveyance towards the water surfaces and using the simulation patterns of the nitrate dynamics in the soil.

The methodology first evaluates the natural vulnerability: the pedo-hydro-climatic characteristics of the area are favourable to the nitrate conveyance to the water surfaces (underwater and surface waters). The area is considered as vulnerable if nitrate sources resulted from agricultural activities are laid over the natural vulnerability.

The first subsystem to be taken into account was the soil: in case the soil permeability is low and the land is in the slope of the mapping unit, there is a potential natural vulnerability through drainage for the surface waters; in case the soil permeability is high and the hydroclimatic balance is short moderate, under excess or in excess, the soil in that mapping unit leads to a potential natural vulnerability through percolation of the ground waters.

The potential natural vulnerability through soil-induced percolation becomes present for the ground waters situated under that soil layer, which have the permeability of the medium or high unsaturated area and are situated at low or medium depth.

If by adding up the favourable conditions of nitrate conveyances to the water, soil, climate, relief and water-bearing characteristics, the natural vulnerable areas overlay the administrative-territorial units (common) in which the nitrate balance from the agricultural activities is positive, then that area is considered as vulnerable to the nitrate pollution from agricultural sources.

Vulnerable areas are classified according to the type of nitrate sources, which may be:

- present sources such as present agricultural activities;

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- historical sources such as the zootechnical coumpunds which operated in the past and are now deallocated.

The assessment of the natural vulnerability can be made through two methods:

a). Touristic methods. The indeces regarding the natural vulnerability for the nitrate pollution of the aquiferous and surface waters are given by the percolation and drainage processes on the slopes.

To the soil characteristics, the method associates values ranging between 0 (no impact) and 1 (maximum impact), classifying the potential impact of the soil characteristics on the nitrate conveyance by percolation to the ground waters or the drainage to the surface waters.

The vulnerability index by percolation is calculated only for the lands with slopes lower than 8% and for the following soil characteristics: hydraulic conductivity, maximum quantity of accessible water, parental material, texture.

The vulnerability index by drainage is calculated only for the lands with slopes higher than 8% and for the same soil characteristics as in the first case.

For each soil type, the sum of the percentages of the different characteristics taken into account for the assessment of the vulnerability to percolation and drainage is calculated. The final vulnerability index is assessed either as the maximum index between the indeces of all soil types or as a weighted average based on the surface occupied by each soil type. The thus determined sum of the percentages is transposed into vulnerability classes such as:

- Very low: [0.0-0.5]
- Small: (0.5-1.5]
- Moderate: (1.5-2.5]
- High: (2.5-3.5]
- Very high: > 3.5

b). Information based on pedological studies at a high scale.

The analysis of the eco-pedological indeces leads to the following classification indeces of the soil-land system into vulnerable or potentially vulnerable to nitrogen.

Table 1. Soil texture

Vulnerability to nitrogen of the soil-land system		
high	medium	low
Coarse sand		
Medium sand		
Fine sand		
Loamy coarse sand		
Loamy medium sand		
Loamy fine sand		
Sediments with over 40% $CaCO_3$		
Gravels		
Organic sediments		
	Coarse sandy loam	
	Medium sandy loam	
	Fine sandy loam	
	Silty sandy loam	
	Silt	
	Sandy-clay loam	
	Medium loam	
	Silty loam	
	Sandy clay	
		Medium clay loam
		Silty clay loam
		Loamy clay
		Silty clay
		Medium clay
		Fine clay

The soil texture being the soil's hardest to modify physical characteristic and influencing the soil's main physical and chemical properties, some technologies and especially the fertility technologies for each soil type texture should be implemented.

Table 2.Soil permeability

K value mm/h	Vulnerability to nitrogen of the soil-land system		
	high	medium	low
< 0.3			Low
0.3 – 0.5			Very low
0.6 – 2.0		Low	
2.1 – 10.0		medium	
10.1– 35. 0	High		
> 35.0	V. high		

Table 3.Land slope

Vulnerability to nitrogen of the soil-land system		
high	medium	low
Horizontal		
Very slightly sloping		
	Slightly sloping	
	Moderately sloping	
		Steep sloping
		V. steep sloping
		Abrupt

Table 4.Surface erosion

Soil loss t/ha an	Vulnerability to nitrogen of the soil-land system		
	high	medium	Low
< 1			Low
2-8	-	-	Small
9-16			
17-30	High	Moderate	-
> 31	Very high	-	

Table 5.Land uniformity

Vulnerability to nitrogen of the soil-land system		
high	Medium	Low
		uniform
	Very slightly non-uniform	
	Slightly non-uniform	
Moderately non-uniform		
Strongly non-uniform		
Very strongly non-uniform		

Table 6.Land floodability

Vulnerability to nitrogen of the soil-land system		
high	Medium	Low
		Non-floodable
Rarely floodable		
Frequently floodable		
Very frequently floodable		

Table 7.Depth of pedo-surface or surface waters

Vulnerability to nitrogen of the soil-land system		
high	medium	Low
Superficial		
Extremely low		
Very low		
Low		
	Medium	
	High	High
		Very high
Coastal springs		

3. RESULTS AND DISCUTIONS

Nitrogen balance from agricultural sources was assessed taking into account:

a). The import of nitrogen in a village which was established based on all the animals in the village:

- present: the number of animals in compounds in 2008
- historical: the number of animals based on the capacity of the decommissioned compounds.

b). The export of nitrogen in a village based on the average harvests for the main agricultural crops, calculated from the appraisal documents (data source: ICPA).

By overlaying the layers for the potential vulnerability induced by the main natural factors and/or nitrate sources, the following situations can be classified:

- Overlaying in the same area of the vulnerability conditions induced by the water-bearing characteristics and by the soil or climate conditions;
- Overlaying in the same area of the vulnerability conditions induced by the water-bearing characteristics and by the soil or climate conditions and by the nitrate positive sources for the administrative-territorial units.

Areas for which the vulnerability conditions induced by soil, climate, ground water characteristics and nitrate positive balance from agricultural activities for the villages as administrative-territorial units are accomplished have as present source the nitrate positive balance and as historical source the past positive balance.

Table 8.The Banat hydrographical space

No.	Village	County	Relief form	Agricultural ha	Arable ha	NO_3 source in the village	
						Present sources	Historical sources
1	Cenei	Timiş	Plain	11,714	10,247		•
2	Foeni	Timiş	Plain	5,817	4,729		•
3	Gătaia	Timiş	Plain	19,541	15,993		•
4	Giarmata	Timiş	Plain	6,634	4,968		•
5	Giulvăz	Timiş	Plain	9,550	7,083		•
6	Jebel	Timiş	Plain	9,968	8,070	•	
7	Maşloc	Timiş	Hill	12,027	9,036		•
8	Peciu Nou	Timiş	Plain	12,198	9,115		•
9	Periam	Timiş	Plain	9,050	7,670	•	
10	Pişchia	Timiş	Hill	9,754	7,197		•
11	Şag	Timiş	Plain	8,622	7,312	•	
12	Sat Chinez	Timiş	Plain	8,979	8,021		•
13	Tormac	Timiş	Plain	12,774	10,937		•
14	Uivar	Timiş	Plain	18,096	15,656		•

4. CONCLUSIONS

The region of Banat is characterised by very highly productive soils. The soils of humid surface chernozeem type with all of its subtypes and vertisoils predominate. The surface water is not found at a very and it reaches the risosphere supplying the agricultural cultures with the necessary water.

The main disadvantages that agriculture brings to the environment is the nitrate, nitrite, ammonium, and pesticides pollution as well as floods, euthrofisation, soil degradation through erosion, soil subsidence, biodiversity reduction, natural habitats degradation, hothouse effect, etc. As far as human health is concerned, with the growth of the nitrate, nitrite and ammonium concentration in the potable water, with the growth of the pesticide residues in the air, water and food, the number of diseases also rises.

Stock raising, through raising and using the animals, represents an important source of soil and surfae water contamination through the wastewaters resulting from animals hygiene, usually spilt into the environment without their prior processing and neutralisation.

The irational use of chemical fertilisers as well as of pesticides, especially herbicides, has led in time to the pollution not only of the surface waters, but also of the underwaters.

Taking into account the main relief form where the localities were classified into, the classification of the vulnerable surfaces is the following:

a). Plain

- The surface of agricultural land in the vulnerable areas is of 529,606 ha representing 6.18% of the total surface of the agricultural lands in the plain area.

- The surface of arable land in the vulnerable areas is of 409,722 ha representing 5.91% of the total surface of the agricultural lands in the plain area.

b). Hill

- The surface of agricultural land in the vulnerable areas is of 187,567 ha representing 6.10% of the total surface of the agricultural lands in the plain area.

- The surface of arable land in the vulnerable areas is of 114,264 ha representing 6.67% of the total surface of the agricultural lands in the plain area.

c). Partial mountain

- The surface of agricultural land in the vulnerable areas is of 71,810 ha representing 8.84% of the total surface of the agricultural lands in the partial mountaineous area.

- The surface of agricultural land in the vulnerable areas is of 30,052 ha representing 10.45% of the total surface of the agricultural lands in the partial mountaineous area.

d). Mountain

- The surface of agricultural land in the vulnerable areas is of 59,846 ha representing 2.51% of the total surface of the agricultural lands in the mountaineous area.

- The surface of agricultural land in the vulnerable areas is of 15,617 ha representing 3.39% of the total surface of the agricultural lands in the mountaineous area.

From these results, it shows that the total srface of the vulnerable areas to the nutrate pollution from effective and historical agricultural sources is:

- The surface of agricultural land in the vulnerable areas is of 1,217,147 ha representing 8.20% of the total surface of the agricultural lands in the plain area.

- The surface of arable land in the vulnerable areas is of 866,961 ha representing 9.22% of the total surface of the agricultural lands.

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