MAPPING THE NITRATE CONTAMINATION LEVELS IN THE GROUNDWATER IN TIMIS COUNTY – A GIS APPROACH

CARTAREA NIVELURILOR DE CONTAMINARE CU NITRAȚI DIN APA FREATICĂ ÎN JUDETUL TIMIS – O ABORDARE SIG

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Abstract: *The aim of this paper is to present an assessment of nitrates fluxes in the groundwater in Timis County using some direct measurements, as well as their spatial distribution. The presence of the high nitrogen concentrations in soils is a high potential risk for the groundwater and, implicitly, for human and animal health, the groundwater being the main source of the drinking water in many rural areas. One of the main risk factor for nitrates pollution is the agricultural activity, through the application of the mineral and organic fertilizers doses. As EU country, Romania has to report to international committees the state of nitrate pollution, in the respect of Nitrate Directive, in order to promote a sustainable agriculture based on suitable agricultural practices application for environmental protection. Several information systems, assessing and monitoring the potential vulnerable zones to nitrates, using pre-established indicators, have been developed. In order to assess the influence of relief and local conditions on the nitrates contents in the groundwater, several measurements have been done using the multiparameter nitrate sonde, for the following parameters: water temperature, groundwater depth and thickness, ammonia, nitrates, chlorophyll, and dissolved oxygen contents. Other observations about local conditions (distances to stables, to other potential sources of contamination, the type of wells, etc) have been done. A NUTS4 administrative unit, vulnerable to nitrate pollution, from Timiş County, has been chosen for these measurements. The environmental conditions of the studied areas are presented. Some relationships between the measured values of nitrate contents in the groundwater and the landscape are presented.*

Rezumat: *Obiectivul acestei lucrări îl constituie evaluarea cantității de nitrați din pânza de apa freatică în județul Timiş utilizând măsurători directe, şi distribuția lor spațială. Prezența concentrațiilor ridicate de azot în sol este un risc potențial ridicat pentru apa freatică, şi, implicit, pentru sănătatea umană şi animală, deoarece aceasta este sursa principală de apă potabilă în multe zone rurale. Unul din principalii factori de risc pentru poluarea cu nitrați îl constituie activitatea agricolă, prin aplicarea de fertilizanți minerali şi organici. Ca țară membră UE, România trebuie să raporteze comitetelor internaționale situația poluării cu nitrați, conform Directivei Nitraților, pentru a promova agricultura durabilă, bazată pe aplicarea lucrărilor agricole adaptate protecției mediului. În acest scop, au fost dezvoltate mai multe sisteme informatice pentru evaluarea şi monitorizarea zonelor potențial vulnerabile la nitrați, folosind indicatori prestabiliți. Pentru a evalua influența reliefului şi a condițiilor locale asupra conținutului de nitrați din apa freatică, au fost efectuate mai multe măsuratori cu sonda multiparametru de nitrați, pentru următorii parametri: temperatura apei, adâncimea apei freatice, grosimea stratului de apă freatică, conținutul de azotat, amoniu, clorofilă şi oxigen dizolvat. Au fost notate şi alte observații despre condițiile locale (distanța până la grajduri, sau până la alte surse potențiale de poluare, tipul fântânii, etc.). A fost ales ca studiu de caz o comună din județul Timiş, Peciu Nou. Sunt prezentate condițiile de mediu pentru arealul studiat, precum şi câteva relații între valorile măsurate ale conținutului de nitrați şi peisaj.*

Key words: *nitrates pollution, vulnerable area, nitrates assessment*
Cuvinte cheie: *poluarea cu nitrați, zonă vulnerabilă, evaluarea cantității de nitrați*

INTRODUCTION

In the frame of adapting the European Union environmental regulation, the nitrates pollution is a main up-to-date issue (DUMITRU et al, 2006).

Many rural localities in Romania use for potable water the public or individual wells, most of them being placed not far from households. On the other hand, many of these villages have no sewer systems or water depuration systems (DUMITRU et al., 2008). Even if these systems will be developed in the future, many villages will use wells water as potable water for a long period of time. Due to relative high concentrations of animals in some villages and to inappropriate practices for housing and manure storage, relative great and unprotected manure quantities will reach the groundwater, determining a potential danger for ground and surface water quality, being a nitrates and other nutrients, as well as bacteria, source. Another pollution sources are the sewage sludge effluents, the waste residues (organic and inorganic) accumulated in the surface water bodies or infiltrated directly in soil, contaminating water in the well water, as well as the solid compost piles. Another problem is the use of manure piles and sewage sludge to fertilize gardens and small agricultural areas, the mineral fertilizers being too expensive for the small households. Therefore, the main objectives, in dealing with the nitrates pollution, focus both on the conservation of existing nutrients and on the maximum efficiency of applied nutrients.

The study area is located on the Timiş Plain, Bega Mică subunit, which is a subsiding plain, swampy, in a clogging stage, characterized by valleys with unstable river beds or channels and easily flooded areas and several abandoned river beds (POSEA, 1997). The aquifer of this area consists of recent alluvial deposits with several sediment types: sand, mud, clayey-sand, loamy-sand, fine gravel. The groundwater is generally unconfined in the alluvial deposit with water table at depths of 1-3 m. Also, there are small areas with water table at depths of 0-1 m characteristic to low land relief.

The climate is moderate temperate continental characterized by hot summers and moderate and short winters (the medium temperatures is positives, 0,2°). The medium annual values of precipitation is 631 mm at Timişioara and the medium annual temperatures is under 11°C (10,9°C at Timişoara). In terms of climate for assessing vulnerability to nitrates pollution, the most important parameter is the ratio between precipitation and potential evapotranspiration. The average value of this ratio, for the climatic year series 1961-1990, considered as reference for climatic impact studies, is 0,887 for the studied area, with a variation between 0,613 and 1,237. Therefore, hydro climatic regime generally induces significant transfers of water from the atmosphere to the water bodies through soil. During the years with fewer precipitations, the annual cumulated value of potential evapotranspiration exceeds that one corresponds to precipitation, the risk regarding the transfer of nitrates to the water bodies form surface and underground being reduced. Rainy years, however, will induce the movement of nitrates stored in such unsaturated zone to groundwater bodies. The present land use pattern indicates that the arable lands are abundant and located in the upper parts of the relief on calcic and haplic chernozem, in the vicinity of Peciu Nou locality. The grasslands are scattered in the north and western part of the study area, on gleyic chernozem and solonetzs.

MATERIAL AND METHODS

Two NUTS4 administrative units, vulnerable to nitrate pollution, from Timis County, have been chosen as case studies: Peciu Nou and Sacalaz. For this paper, the Peciu Nou measurements are discussed and presented.

In Peciu Nou, groundwater measurements were done for 25 locations (wells, drills, and channel) in April 2008 (Table 1), in 3 villages. Most wells are used for agricultural

purposes, especially for irrigation of home vegetable gardens, and few for drinking water. The sampling locations have been recorded using the Global Position System (GPS) and also photos of each well have been taken for a complete identification. The measurements have been done using the Hydrolab DS5 Water Quality Multiprobes Sonde for in-situ and flow-through applications (figure 1). Using a series of sensors, the following parameters have been measured simultaneously: water temperature, groundwater depth, groundwater thickness, ammonia and nitrates amounts, water pH, chlorophyll content, and dissolved oxygen content. Other observations about local conditions such as: distances to stables or to other potential sources of contamination, the type of wells, etc. have been done.

Figure 1. The Hydrolab DS5 Water Quality Multiprobes Sonde and its display

All data were assembled into a single composite database to facilitate the analysis. The database includes well ID, locality, well use, geographic coordinates, concentration, measurement date, aquifer, basin, soil type, watershed, and sampling depth. The data is available in a format that is accessible via GIS. The use of GIS tools, techniques, and capabilities enabled data processing, visualization, computation, analysis, and map preparation.

Table 1

Number of wells for each village in Peciu Nou Communa

Nr. crt.	Village name	Number of measurements				
		total	field wells	drilling	unused wells	channel
1	Peciu Nou	12	1	4	4	1
2	Sanmartin Sarbesc	7		2	1	
3	Dinias	6	1	1		

Interpretation of ammonia and nitrates content from groundwater has been made according to the Law no. 458/2002 of Romanian Parliament regarding the quality of potable water and establishing the Maximum Contaminant Level as being 50 mg/l NO_3 and 0.5 mg/l NH_4.

RESULTS AND DISCUSSIONS

Peciu Nou is situated in a vulnerable to nitrates pollution area. The Action Plan established by The Ministry of Agriculture and Rural Development, recommends for this commune maximum 3.2 UVM/ha. The nitrates balance, defined as difference between the input nitrogen amount from organic fertilizers and that extracted by crops from soil is -267.043 t N/year, representing -33 kg N/ha/year. The corrected nitrates balance (due to households

input) is -204.721 t N/ha, or -25 kg N/ha/year (Simota, 2008). A main cause of the nitrates pollution of soil groundwater is its relative slow gradient of flow, and its relative small depth, the groundwater table being near the surface.

The location for each well is mapped in fig. 2. The database also holds information about geographic coordinates, elevation, the main measured parameters, as well as notes and photos for each well.

The main measured parameters for all the 25 locations are presented in Table 2, as well as some notes for each well, regarding the well location, the owner, the distance to possible source of pollution (stable, WC), or if the well water is potable or not.

The table shows that the depths to the groundwater table are higher in Peciu Nou (2-4 m), and Sânmartinu Sârbesc (3-4 m), than those measured in Diniaş (1-2 m), the last village being situated in a relatively low land area, as shown in the map. The groundwater thickness has relatively small values, being larger in Diniaş (even 2-3 m), than in the first two villages. One of the measurements has been done in a drainage channel, in the field, between Peciu Nou and Sânmartinu Sârbesc, and another two in open field wells, located near the built-up areas of Peciu Nou and Diniaş. The temperature T, nitrates NO_3, ammonia NH_4, and pH values for each of the 25 locations (17 wells, 7 drills and 1 channel) have been presented in fig. 3. The chart highlights that the maximum nitrates NO_3 value that could be measured using the Multiprobes Sonde (100 mg/l) has been recorded in 11 locations (9 of them being wells), and in another 4 wells the Maximum Contaminant Level (50 mg/l) for nitrates in drinking water has been overcame. The ammonia contents (NH_4 values) for these locations are very high, with values ranging from 1.72 mg/l to 4.53 mg/l, indicating that the source of contamination could be the non-septic pits latrine, in which the human manure infiltrates directly to the groundwater. Only in 10 locations, the NO_3 values are smaller than the Maximum Contaminant Level (2 field wells, 2 other wells, 3 drill measurements, 1 channel, and 2 measurements from public water system). The corresponding NH_4 values are smaller than MCL.

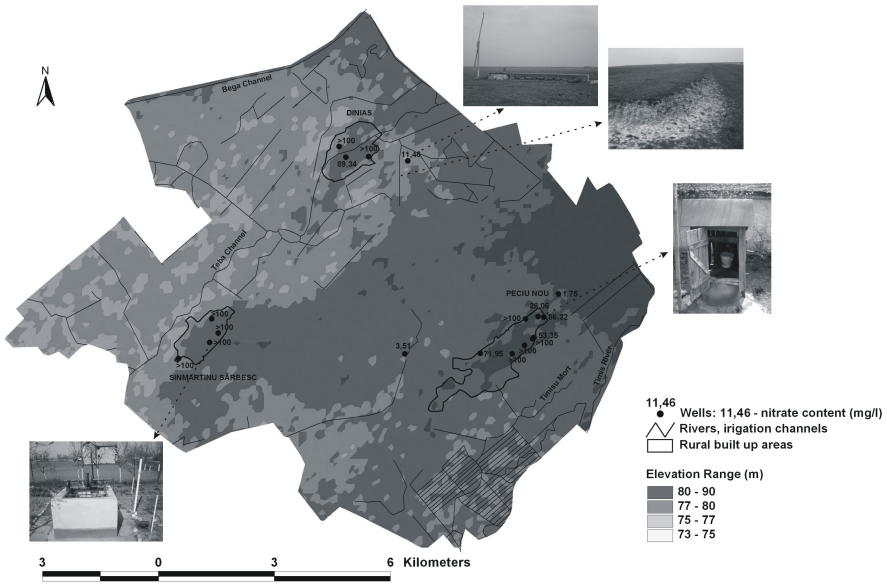

Figure 2. The Peciu Nou commune, Timis County, map, wells location, photos.

Table 2

Nitrates Measurements in wells for Peciu Nou

No.	Village	Elevation	Ground water thickness (m)	Depth to WT (m)	Temp (^{0}C)	NH_4 (mg/l)	NO_3 (mg/l)	pH	CHL	Notes
1	Peciu Nou	68	1,68	4	9.70	0.22	1.75	8.24	4.570	field well
2	Peciu Nou	88	0.88	3	9.76	0.13	86.32	8.89	2.290	personal well, near the road
3	Peciu Nou	88			12.09	0.15	>100.00	7.83	0.230	drill
4	Peciu Nou	88			10.96	0.08	6.23	8.21	0.950	public water system
5	Peciu Nou	105	1.35	2	9.87	0.24	28.06	9.19	2.540	unused well
6	Peciu Nou	72	0.78	2	10.30	0.23	>100.00	8.16	1.320	personal well
7	Peciu Nou	89	1.80	3	9.72	0.89	53.35	8.30	1.120	unused well
8	Peciu Nou	89			12.18	1.72	>100.00	7.60	0.040	drill, 15 m
9	Peciu Nou	91	1.00	4	9.35	3.73	>100.00	9.30	3.980	unused well, with bricks
10	Peciu Nou	94	1.31	4	10.71	4.07	>100.00	8.88	0.890	personal well, with bricks
11	Peciu Nou	87	2.08	3	11.48	0.88	71.95	8.30	0.520	drilling; poultry
12	Peciu Nou	85	0.07	3	14.70	0.12	3.51	8.84	3.760	drainage channel
13	Sanmartin Sarbesc	109	1.20	3	9.71	2.63	>100.00	8.57	1.560	well used for irrigation
14	Sanmartin Sarbesc	109			13.19	0.13	1.68	8.44	16.090	well used for potable water
15	Sanmartin Sarbesc	77	1.63	2	9.52	1.26	>100.00	8.90	3.490	public well
16	Sanmartin Sarbesc	77			12.74	0.13	21.70	8.39	2.260	drill, 56 m
17	Sanmartin Sarbesc	87			11.79	0.19	>100.00	8.66	1.350	personal well
18	Sanmartin Sarbesc	87			11.99	0.07	2.43	8.53	2.750	drill, 76 m
19	Sanmartin Sarbesc	83	1.29	3	9.20	3.45	>100.00	9.01	2.670	personal well, near a WC
20	Dinias	90	2.10	1	8.96	0.31	>100.00	8.68	6.270	personal well
21	Dinias	88	3.20	1	7.69	0.09	11.46	8.93	17.850	field well
22	Dinias	88	0.42		7.91	0.08	10.37	9.06	4.860	public water system
23	Dinias	87			11.29	0.16	89.34	7.87	1.280	personal well
24	Dinias	87			10.89	0.11	2.56	8.10	1.460	drill, 60 m
25	Dinias	76	1.58	2	9.04	4.53	>100.00	8.82	2.550	personal well

The nitrate contents from wells located in open field on arable and pasture lands are very low (1.75-11.46 mg/l), indicating no contamination of groundwater from agricultural sources. Other low values for nitrate contents have been recorded for samples from the public water system, and for samples from drills, 50-70 m depth, from deeper aquifers.

In the same time, the nitrate contents from wells located in villages are very high, exceeding the threshold of 50 mg/l, the possible source being the non-septic pits latrine, causing an increased content of NH_4 (1.72 mg/l to 4.53 mg/l).

The values for NH_4 content are, generally, greater than the Maximum Contaminant Levels for 9 measurements, all of them having the NO3 values greater than 50 mg/l. The highest ammonia content is recorded in Diniaş village (4.53mg/l), situated in a lower area than the other two villages, indicating a more strong nitrate pollution in that area.

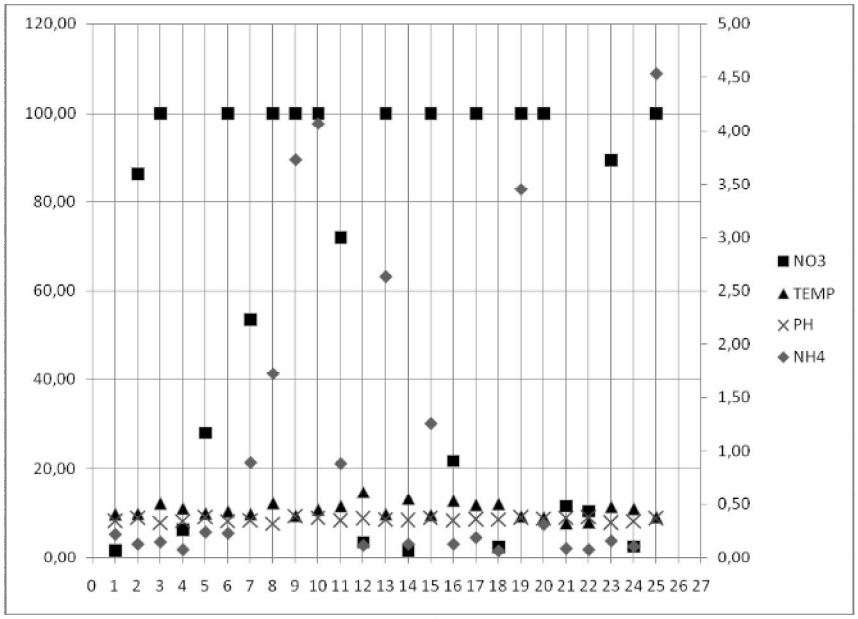

Figure 3. NO3, NH4, pH, and T values for Peciu Nou commune, Timis County

CONCLUSIONS

The values for measured NO_3 and NH_4 are generally quite high, larger than the Maximum Contaminant Levels for drinking water (50 mg/l), meaning that the studied area have problems with polluted groundwater. The Peciu Nou commune is a vulnerable area to nitrates pollution; therefore, an action plan to deal with this groundwater threat has been developed.

The nitrate contents from wells located in open field on arable and pasture lands are very low (1.75-11.46 mg/l), indicating no contamination of groundwater from agricultural sources.

The nitrates values from wells located inside the villages are very high, exceeding the Maximum Contaminant Level (50 mg/l), in some cases exceeding 100 mg/l. The high ammonia contents, ranging from 1.72 mg/l to 4.53 mg/l, could indicate as source of contamination the non-septic pits latrine, in which the human manure infiltrates directly to groundwater.

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