THE NUTRIENT MANAGEMENT PLAN AT FARM LEVEL

PLANUL DE MANAGEMENT AL NUTRIENTILOR LA NIVEL DE FERMA

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Abstract: *At European level, people and policy makers are very concerned with environment issues, one of the main problems being the nitrates contamination of groundwater. The agricultural activities are the main nitrogen supply in soil, due to the application of the mineral and organic fertilizers doses. In the last decades, worldwide there was an increasing tendency for using nitrogen based fertilizers, being well known that it represents an essential nutrient for conservation and/or amelioration the soil fertility state and for agricultural production, which has to satisfy the food needs of increasing population. The presence of the high nitrogen concentrations, exceeding the maximum admissible concentrations may have a negative impact of the environment through the possible losses in the ground and surface waters and/or atmosphere. In order to optimize the crop production and avoid the environmental contamination with nitrates, a nutrient management plan (NMP) at farm or village level has been developed. The need of such a tool is given by the fact that the polluted groundwater, mostly in the nitrates vulnerable communes (NUTS4 level), is used for potable water through the public or individual wells, most of them being placed not far from households. The management plan for (organic and mineral) nitrogen fertilizers is based on the description of N cycle in soil-plant-hydrosphere system, taking into account the following soil N forms: inorganic nitrogen (nitrates), organic nitrates from vegetal residues incorporated in soil, organic nitrates in active and stable form associated with soil humus stock, organic nitrates from organic manure. The nitrogen alteration processes between different N forms (humus mineralization, vegetal residues decomposition and the associated mineralization, denitrification and immobilization) are described through equations for chemical kinetic associated, the reaction speed being influenced by temperature, soil moisture, and the different nitrogen amount from each form types. Mineral nitrates flux percolating under the roots depth (leaching) is calculated as function of water drained flux and average nitrates concentration on soil profile. The nutrient management plan application has been developed as a MS Excel file, using VBA language. The NMP components, its inputs and outputs data, and the main worksheets are described. A case study for a commune is presented, highlighting the accessibility of the application and its usefulness for the farmers and other local stakeholders, as well as for local authorities.*

Rezumat: *La nivel European, publicul larg si factorii politici sunt preocupati de problemele de mediu, una din cele mai importante fiind contaminarea cu nitrati a apelor freatice. Activitatile agricole sunt principalul contributor al azotului din sol, datorita aplicarii fertilizantilor minerali si organici. In ultimele decenii, peste tot in lume a crescut tendinta de a utiliza fertilizanti pe baza de azot, deoarece acesta este un nutrient essential pentru conservarea si/sau ameliorarea starii de fertilitate a solului si a recoltei, care trebuie sa satisfaca necesitatile hrana ale unei populatii in crestere. Prezenta unor concentratii ridicate de azot, peste maximul admisibil poate avea un impact negativ asupra mediului prin posibilele pierderi catre apele de suprafata si de adancime si/sau atmosfera. Pentru a optimiza recolta si pt a evita contaminarea mediului cu nitrati, a fost dezvoltat un Plan de Management al Nutrientilor la nivel de ferma. Nevoia dezvoltarii unui astfel de plan a fost data de utilizarea apei freatice, mai ales in comunele vulnerabile la nitrati ca apa potabila, prin fantanile publice sau individuale, multe din acestea fiind plasate in apropierea grajdurilor. Planul de management al fertilizantilor (organic si minerali) se bazeaza pe descrierea ciclului de azot in sistemul sol-planta-atomosfera), prin luarea in consideratie a mai multor forme de azot: azotul anorganic (nitratii),*

azotul organic din reziduurile vegetale incorporate in sol, azotul organic in forma activa si stabile asociate cu rezerva de humus, precum si cel din gunoiul de grajd. Procesele de alterare a azotului intre diferitele forme (mineralizarea humusului, descompunerea rezidurilor vegetale si mineralizarea asociata, denitrificarea si imobilizarea) sunt descrise prin ecuatii chimice, viteza de reactie fiind influentata de temperatura, umiditatea din sol, si de cantitatea diferita de azot in diverse forme. Fluxul de nitrati minerali care percoleaza sub adancimea de inradacinare este calculat ca functie de fluxul drenat de apa si de concentratiile medii de nitrati pe profilul de sol. Planul de management al nutrientilor a fost realizat ca o aplicatie intr-un fisier MSExcel, utilizand limbajul VBA. Sunt descrise in lucrare componentele NMP, datele de input si output, precum si principalele worksheet-uri. Este prezentat un studiu caz pt o comuna din judetul Timis, evidentiind accessibilitatea aplicatiei, precum si utilitatea pentru fermieri si alti stakeholder locali, ca si pentru autoritatile locale.

Key words**:** *nutrients management plan, nitrates pollution, soil and climate databases*
Cuvinte cheie**:** *planul de management al nutrientilor, poluarea cu nitrati, bazele de date de sol si clima*

INTRODUCTION

The nutrients management is an up-to-date issue in the last period, in the frame of adapting the European Union environmental regulation. The main problem is the groundwater pollution (DUMITRU et al., 2006), mostly in the nitrates vulnerable communes (NUTS5 level), leading to the potable water pollution from public or individual wells, most of them placed not far from households. The main source of pollution is the relative great and unprotected manure quantities reaching the groundwater, being a potential danger for ground and surface water quality. 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.

The nutrients management plan at NUTS5 level has been developed in the frame of a large action plan at the Vulnerable Area to Nitrate Pollution (NUTS4) level, designed in order to prevent, reduce or retrieve surface and ground water bodies pollution with nitrates from agricultural sources in areas assigned as Vulnerable or Potential Vulnerable Areas to Nitrate Pollution. This plan holds the main measures that should be taken by farmers as well as by local authorities, having also an important role in public awareness, information dissemination and in measures applications tracking.

The plan takes into consideration the needs of actual crop, the vegetal residues of previous crop, the further increase of nutrients pressures (in the terms of kg N manure per hectare available for disposal), as well as the increasing livestock (leading to increasing areas for manure recycling). The individual farms could sometimes share the manure amounts with their neighbours. The aim of the present Nutrient Management Plan is therefore: a safe disposal of sewage sludge and other organic residues; the insurance of minimum environmental losses of nutrients, as well as minimum transport costs, and an efficient nutrients use for the crop.

MATERIAL AND METHODS

The Nutrient Management Plan (NMP) has been developed at a NUTS5 level in the frame of a large action plan at the Vulnerable Area to Nitrate Pollution (NUTS5) level, designed to prevent, reduce or retrieve surface and groundwater bodies pollution with nitrates from agricultural sources in Vulnerable or Potential Vulnerable Areas to Nitrate Pollution. This plan holds measures that should be taken by farmers as well as by local authorities, which have also an important role in public awareness, information dissemination and in measures applications tracking. The action plan include also a monitoring program for these water bodies, as well as a plan with suitable measures enforced in the large animal husbandries

complexes, under Environmental Protection Agency and/or other Water Organisms control.

The plan takes into consideration the further increase of nutrients pressures (in the terms of kg N manure per hectare available for disposal), as well as the increasing livestock (leading to increasing areas for manure recycling). The individual farms could sometimes share the manure amounts with the neighbours.

The Nutrients Management Plan is developed using soil maps 1:200 000, the Soil Monitoring database and European Climatic Database from ATEAM Project, or measured climatic data, as well as the Soil Pedotransfer Functions Database.

The management plan for (organic and mineral) nitrogen fertilizers is based on the description of N cycle in soil-plant-hydrosphere system, taking into account the following soil N forms: inorganic nitrogen (nitrates), organic nitrates from vegetal residues incorporated in soil, organic nitrates in active and stable form associated with soil humus stock, organic nitrates from organic manure. The nitrogen alteration processes between different N forms (humus mineralization, vegetal residues decomposition and the associated mineralization, denitrification and immobilization) are described through equations for chemical kinetic associated, the reaction speed being influenced by temperature, soil moisture, and the different nitrogen amount from each form types. Mineral nitrates flux percolating under the roots depth (leaching) is calculated as function of water drained flux and average nitrates concentration on soil profile.

The time step for calculation is monthly average. The used equations are similar to those of SWAT methodology (Neitsch et al., 2001). The water balance in soil-plant-hydrosphere system (potential and actual evapotranspiration, drainage) is based on Thornthwaite-Mathers method (Thornthwaite et al., 1957), using average monthly air temperature and accumulated monthly precipitations.

The Nutrients Management Plan is developed using an interactive application – a workbook in Microsoft EXCEL^{TM}. Running the application, the management plan (mineral fertilizers amount for a balanced fertilization) for a certain crop (type and expected yield), the previous crop (type, yield, the vegetal residues management) and manure using from a farm is calculated.

The “Plan Management” folder holds: the pmn.xls file; the pmn.doc (describing the procedure); two climatic databases using a 10 x 10 km grid, for two series of years 1960-1990 and 1990-2000; a shMeteo.exe file to extract climatic data for a specific commune, two .txt files holding the climatic data for the specific commune, and some library files. The climatic data were obtained from ATEAM European project (New et al., 2000; New et al., 2002; Mitchell et al., 2004). The software main menu is presented in fig. 1. Each subroutine is called using a button.

The following inputs are used: soil type; soil parameters; farm localization and area; meteorological data, number of animal; the manure application way; the expected yield; the previous yield, as well as the percent incorporated in soil.

For each TEO designed using complex soil survey studies (using 1:10 000 scale for plain and hilly areas and 1:5 000 scale for mountain / partial mountain areas), the minimum soil parameters are: soil type, soil textural classes, morphological soil characteristics, nation land marking for main crops. The soil morphological and physico-chemical characteristics are evaluated using at least a soil profile. Facilities for indirect assessment of different parameters (when analytical data are missing) are included in the application, using soil type, textural classes and land use classes, through the pedotransfer functions and rules database developed by our institute.

The average monthly air temperature and precipitation values are necessary. If these values are not available, the application uses a database with monthly air temperature and

precipitation values on a 10 x 10 km grid for two series of years 1961-1990 and 1991-2000.

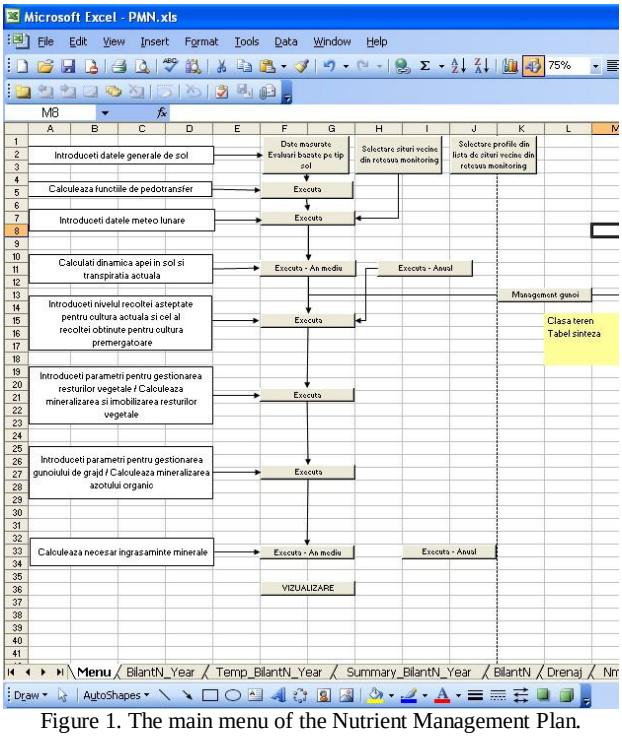

Figure 1. The main menu of the Nutrient Management Plan.

The input data regarding the previous and the expected yields could be chosen by the user, the software having a component assisting the user to evaluate the average yields for different crops for each commune. The nitrogen used by plants is further calculated by a specific subroutine using the transfer coefficients provided by the Code for Good Agricultural Practices.

The vegetal residues from previous crop are evaluated as function of two parameters provided by the user: the percent of secondary yields incorporated in soil and the date of incorporation.

The livestock owned by each farmer is specified. Also, the manure collecting and storage methods, as well as storage period are specified. If it is necessary, the starting and ending date for grazing, as well as the manure storage method for grazing period are specified. If the manure quantity is higher than the Nitrates Directive recommendations, the application warns the user in order to share the exceeding with other farmers.

The final result of the software is the assessment of mineral fertilizers necessary to balance the nitrates export to the present crop, as well as the nitrates flux leached under the root depth. This leached flux is evaluated according to the application date and to the applied quantities (with an interface interactive for the user). Therefore, the outputs are as follows: the animal concentration (UVM / ha), the nitrates amount for the expected yield, the mineralized nitrogen from vegetal residues, and from manure, the immobilized nitrogen, as well as the nitrogen leached. The final output is the needed mineral fertilizers, used for a uniformed fertilization.

RESULTS AND DISCUSSIONS

The Nutrient Management Plan (NMP) has been used for two particular communes from Timiş County: Sânadrei and Lovrin. A medium farm having 2000 ha has been chosen for running the NMP.

There are three ways to obtain the input soil data needed in the implementation of NMP: direct measurements, indirect evaluation using pedotransfer functions, or using a soil profile from Monitoring database. Therefore, for each commune, an experimental measured profile has been chosen, as following: for Sânandrei: Mollic Preluvisol (Romanian Soil Taxonomy) and for Lovrin: Typical Chernozem (RST). In order to use the Pedotransfer Functions Database, the soil type and its texture are chosen from the soil map 1:200 000, as following: an Argic Chernozem, for Sânandrei, and a Typical Chernozem for Lovrin. From the Monitoring Database, a Vertic Chernozem for Sânandrei, and a Typical Chernozem for Lovrin have been chosen. All these profiles are presented in table 1.

Table 1

Soil main parameters needed for Nutrient Management Plan

Soil parameters	MU	An experimental measured profile	Using Pedotransfer Functions Database	A profile from Monitoring Database
Sanandrei		**ELmo**	**CZar**	**CZvs**
Organic matter	%	2.34	3.75	2.37
Bulk density	g cm^{-3}	1.42	1.52	1.47
Roots depth	cm	100	100	100
Clay	%	38.4	42	39.2
Silt	%	32.9	25.5	29
Sand	%	28.7	32.5	31.8
Ploughing depth	cm	20	20	75
$CaCO_3$	%	0	0	0.07
Lovrin		**CZti**	**CZti**	**CZti**
Organic matter	%	3.81	4.38	3.3
Bulk density	g cm^{-3}	1.41	1.25	1.25
Roots depth	cm	100	100	100
Clay	%	39	42	29
Silt	%	34	25.5	24.6
Sand	%	30	32.5	46.4
Ploughing depth	cm	20	20	75
$CaCO_3$	%	0	0	9.82

The climatic data have been obtained using shMeteo.exe software, from ATEAM Climatic Database, using the communes coordinates as following: for Lovrin: 20.68^0 E and 45.95^0 N, and for Sanandrei: 21.18^0 E and 45.88^0 N.

The actual crop is considered to be maize – 12000 kg/ha, while the previous crop is winter wheat – 6000 kg/ha. Only 10%m from previous secondary crop has been incorporated in soil. A medium number of 1.5 UVM/ha has been taken into consideration. With these considerations, the nitrates amount for the expected yield, the mineralized nitrogen from vegetal residues, and from manure, the immobilized nitrogen, the nitrogen leached, as well as, the needed mineral fertilizers, used for a uniformed fertilization, has been calculated using the NMP. The results are shown in table 2, highlighting the differences between the 3 different ways to take into consideration the soil parameters.

Table 2

Main outputs for Nutrient Management Plan

Soil type	The N supply for actual crop	The amount of mineralized N from humus and manure	The amount of mineralized N from organic residues	The amount of retained N	The amount of drained N	The amount of mineralized drained N	Mineral fertilizers supply
Sanandrei							
ELmo	330	29	2	1	23	1	323
CZar	330	29	2	1	6	0	306
CZvs	330	29	2	1	6	0	306
Lovrin							
CZti	330	29	2	1	14	1	314
CZti	330	29	2	1	82	4	382
CZti	330	29	2	1	92	6	392

CONCLUSIONS

The governmental politics implementation concerning the decrease of nitrates pollution in soil, surface and ground water in Vulnerable or Potential Vulnerable areas to Nitrate Pollution needs a powerful tool to evaluate and monitoring the impact of measures on environment quality. For this purpose, a nutrients management plan at farm level has been developed, in order to transfer to the local communities the information related to: the importance of a balanced nutrients inputs and outputs in farms having livestock, the identification of potential indexes characterizing the unbalanced nutrients management at the farm activities level, awaking the main strategies to solve the unbalanced nutrients management at the farm activities level.

The case studies for two communes from Timiş County highlight not so much differences between the NMP outputs by using different inputs for soil parameters, especially for Sânandrei (the differences being 5%), while for Lovrin the difference between using the measured soil parameters and the existing database is approximately 20%.

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