THE SOIL AND WATER QUALITY MONITORING SYSTEM REGARDING THE NITRATE CONTENT FROM AGRICULTURAL SOURCES

MONITORIZAREA CALITĂȚII APEI ŞI SOLULUI CU PRIVIRE LA CONȚINUTUL DE NITRAȚI PROVENIȚI DIN SURSE AGRICOLE

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Abstract: *This paper aims to present the actual situation of soil and water quality monitoring system and also the guidelines for its development according to European Union demands concerning water protection against nitrate pollution from agricultural sources.*

Rezumat: *Lucrarea de față îşi propune să prezinte situația actuală a monitorizării calității apei şi solului, precum şi liniile generale de urmat în vederea dezvoltării acestui sistem în conformitate cu cerințele Uniunii Europene referitoare la protecția apelor împotriva poluării cu nitrați proveniți din surse agricole.*

***Key words*:** *nitrates, monitoring, water quality, soil quality*
***Cuvinte cheie*:** *nitrați, monitoring, calitatea apei, calitatea solului*

INTRODUCTION

The intensive development of livestock industry has determined significant increases of animal manure quantities which, inadequate managed, have led to water quality deterioration, especially in the areas with insufficient land, by pollution with nitrates from agriculture.

The European Community has taken legislative measures regarding water pollution with nitrates. The most important is the Directive no.91/676/EEC regarding water protection against nitrate pollution from agriculture sources, and its implementation in Romania will produce major changes in the agriculture. In Romania there have been designated 255 vulnerable zones (NVZ communas).

One of the main demands of this directive for our country is to set and develop a national integrated monitoring system of surveillance, control and decision for pollution decreasing. The monitoring system will combine two interactive components: water subsystem and soil subsystem.

In order to accomplish this present monitoring system will be used at maximum level. This system is constituted from: The Soil Monitoring System, with a 4 years measurement frequency, organized by the Research and Development Institute for Soil Science, Agrochemistry and Environment Protection in close connection to County Offices for Soil Science, and The National System for Water Quality Surveillance, managed by the National Administration „Romanian Waters". To be mentioned is the fact that in present there are no databases about the water quality of the numerous wells from which a great part of the rurale inhabitants is supplying with.

MATERIALS AND METHOD

Efforts have been made to propose an efficient and cost effective system of monitoring, taking into account the facts that: the main sources of drinking water in the rural areas are shallow wells situated within the inhabited areas; at present surface waters are less, or only indirectly, threatened by pollution from agricultural sources than groundwater; at present the highest nutrient pressure is found within in the rural centers and on land in the immediate vicinity of the villages, rather than on more remote agricultural land; monitoring will take place on a collective basis, rather than on an individual basis; therefore monitoring measures applicable to individual farms such as animal complexes for instance in the framework of their operating licenses, are not included; monitoring of nitrates in the soil can at the same time serve the purpose of improving the fertilizer recommendations in areas where such tools are in general not available or affordable for the majority of the farmers (in particular the smallholdings).

It has further been assumed that maximum use will be made of existing monitoring networks, and that existing institutions, government bodies or other organizations will be called upon to develop and execute the future monitoring systems, under the coordination of the Ministry of the Environment and of the water basin management committees.

At present no comprehensive central database, whether digital or analog, is available on the water quality of the numerous shallow water wells that are used by large parts of the rural population for their daily water supply.

A search carried out in the framework of the current assignment reveals that checks of the water quality in the local wells were at best carried out and used at a local scale by different official instances and private organizations, but no efforts were made so far to put data into a central database or register.

More information is available on the occurrence of nitrate related diseases. A recent study by dr. Dr. Anca Tudor of the Public Health Institute of Bucharest reveals that the number of methemoglobinemie cases in the period of 1997 to 2004 changes from year to year, but without showing a clear upward or downward trend.

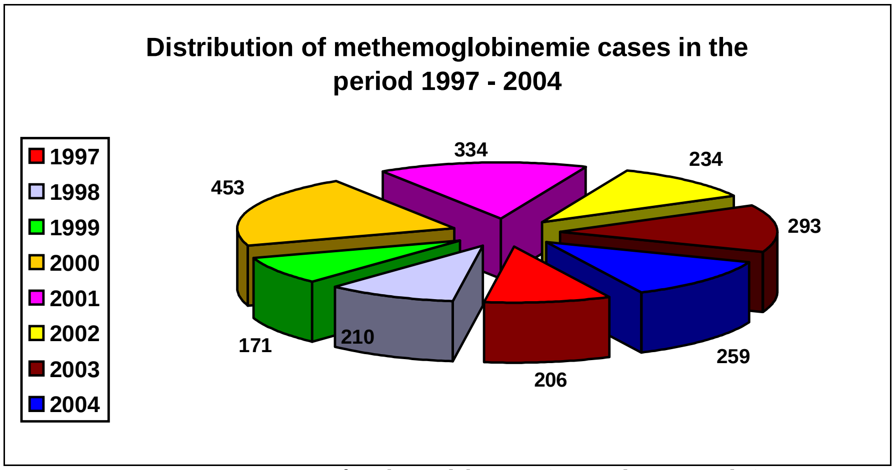

Figure 1. Occurrence of methemoglobinemie (source dr. Anca Tudor)

At present, the National Administration “Apele Romane” (Romanian Waters) administers a network of 1205 piezometric measuring points, scattered more or less evenly over the national territory. In line with the geographic distribution of the freatic groundwater bodies, the mountain regions have fewer monitoring points. The network density is also low in the whole of the Dobrogea region. In the Banat basin and in particular in the Buzau-Ialomita basin, the number of wells is relatively high.

Table 1

Number of wells per large river basin

Basin	**Number of wells**
Jiu	105
Prut-Birlad	114
Olt	116
Dobrogea_litoral	10
Somes-Tisa	81
Banat	162
Dunare	13
Arges-Vedea	81
Siret	118
Buzau-Ialomita	257
Mures	59
Crisuri	89

The National Administration “Apele Romane” (Romanian Waters) is disposing digital data (GIS) on surface water monitoring from a network consisting of 126 sampling points. Out of the 126 sampling points, only 19 are situated within the boundaries of the NVZ communes.

A system of soil quality monitoring has been established in Romania as part of the National System of Environment Quality Monitoring, but for several reasons failed to produce the expected results. Since 1992, a new soil monitoring system for both agricultural land and forest land has been put in place. The network comprises a grid of 942 sites, with a spacing of 16 k x 16 km, 670 whereof are on agricultural land and 272 on forest land, and is structured according to the rules of the Convention on Long Range Transboundary Pollution. At the intersection of every grid, a 400 m x 400 m square is defined for recording a range of soil and terrain parameters, including soil organic matter and available phosphorus. The system is compatible with the Pan European soil network.

RESULTS AND DISCUSSION

All NVZ communes are required to provide a list of the shallow drinking water wells present on their territory. In the first year of the campaign, all the selected wells (estimated at 14.000) should be visited and measured at least once.

Based on the results of the first year of indicative nitrate screening, wells will be classified in the following categories:

- 0 - 10 ppm nitrate and no exceeding of other parameters: water considered fit[1]’ for consumption, no priority for further monitoring
- 10 - 25 ppm nitrate and no exceeding of other parameters: considered fit for consumption, second priority for further monitoring
- 25 - 50 ppm nitrate and no exceeding of other parameters: water considered fit for consumption, first priority for further monitoring

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[1] *In this campaign, not all the quality parameters for drinking water quality are checked. Therefore the results of the screening are only indicative, and a complete analysis, including bacteriological parameters, should be carried out before the water from any well can be officially declared safe for human consumption*

- 50 - 100 ppm nitrate: water considered unfit for consumption, well should be taken out of service (for human consumption) until level of nitrate has dropped below the norm
- > 100 ppm nitrate: water from this well should be declared unfit for human consumption

Every year an update is made of the monitoring plan. The new scheme will include all wells with nitrate concentrations in the previous year above 50 ppm, wells with nitrate concentration between 25 and 50 ppm, wells with nitrate concentrations between 10 and 25 ppm in the previous year.

Wells with previous nitrate concentration below 10 ppm can be dropped from the list and be replaced by new wells not sampled in the previous campaigns. Wells with concentrations below 50 ppm can be dropped from the list when the water quality is showing improvement (beyond the uncertainty limits of the measuring tool) in three consecutive years.

Wells with nitrate concentrations over 50 ppm in three consecutive years should be withdrawn permanently from the public net when no significant improvement is observed or is to be expected.

The scheme will ensure a form of rotation. In case the rotation system does not allow measuring all wells at least once every three years, the number of wells in yearly sample has to be increased.

Groundwater monitoring via sampling of well tubes is relatively expensive because of the high initial installation cost and the operational cost for sampling and analysis. Moreover, groundwater monitoring schemes, when not strategically installed, may yield no or little relevant information on the actual groundwater quality and its evolution. Therefore it is advisable to limit the initial number of wells and to make maximum use of existing wells. On the other hand, existing wells should only be withheld in the network if they are appropriately located, have the appropriate depth and are of suitable quality. This means for instance that wells that are too far away from the monitoring location or that are damaged, silted up or polluted (except through the groundwater) are of no use for quality monitoring, even though they may still be used for the monitoring of the groundwater level.

The current monitoring system for surface water would not provide all relevant information needed in the framework of the nitrate directive, because of the limited number of monitoring points situated within or in the vicinity of the NVZ communes and the size of the basin areas covered by each monitoring point.

From the results of the survey held in the framework of the current assignment, it appeared that direct nutrient losses to rivers or other water bodies, originating from agricultural sources are limited; or can be greatly reduced by applying a series of measures regarding livestock housing manure storage and general nutrient management. Surface water is at present not or very seldom used as a direct source of drinking water but on the other hand the ecological quality of surface waters is very sensitive to small changes in nutrient load. Much more than in groundwater, phosphorus plays a role in the quality assessment of surface water bodies. In general, the water quality of surface waters is much more subject to change in time than the groundwater quality. Therefore, the screening should consist of at least two measurements per point, one in the springtime and one in the autumn.

Later monitoring should be carried out at a rate of at least four times per year. In points with consistently better water quality during two consecutive years, the frequency can be reduced to one or two samples per year.

The effects on the soil of the measures taken in the framework of the implementation of the nitrate directive can be divided in short term effects and long term effects.

On the short term, improved manure storage and better nutrient management should lead to lower nitrate residues in the soil around the storage facilities and on the agricultural land where animals are held of where manure and other fertilizers are being spread. This means lower risk of loss of nitrogen from the soil profile to the groundwater during the periods of precipitation surplus, essentially the late autumn, winter and early spring seasons.

On the long term, reduction of manure pressure leads to lower nutrient reserves in the topsoil, whereby phosphorus and carbon content are suitable indicators to monitor such changes. As phosphorus content of undisturbed land is in general low, and as phosphorus is not very mobile in the soil and therefore tends to accumulate, this element is a good indicator to identify land that has received excessive rates of manure or mineral fertilizers in the past.

In practice, phosphorus reserves of Romanian soils have been, and still are, rather low. Therefore further general reduction of these reserves is in no way an aim to pursue. To the contrary, careful management is needed to restore and to maintain basic fertility of the Romanian agricultural land. Only on land with excessive content of phosphorus (> 250 ppm) measures should be taken to stop further accumulation, such as reduction of the annual application. At present, it is not clear whether such land is to be found within the borders of the NVZ communes. Possible areas with excessively high P levels are fields in the vicinity of (former) livestock complexes where in former times manure was dumped during long periods and at rates far above the agricultural requirements. Such areas however have to be identified and inventoried as yet.

For this and other reasons explained above, specific monitoring of the phosphorus status (in the framework of the nitrate directive) is not a high priority at present. On the other hand, it would be interesting to make an inventory of all agrichemical studies carried out in the past by the OSPA laboratories in particular of the agricultural fields around the livestock complexes, in order to identify any area with a potentially high P-status. Moreover, data on the P status of the topsoil can yield valuable information on the groundwater status of the area. In contrast with nitrogen, phosphorus is a rather stable element in the soil and therefore a currently high P status is a good indicator of systematic manure or fertilizer overdoses in the past, the effect whereof can be seen in the groundwater under the form of high nitrate contents.

More important is the monitoring of the nitrate residues in the autumn. In particular in the areas around groundwater wells and in the recharge areas of the groundwater tables, yearly sampling and analysis of nitrate in the soil profile (0 - 90 cm) should be carried out in order to assess the effect of the measures taken on the level of the residues.

Determination of nitrate residues can also be used as a means to verify the respect of the manure dosage. Norms for admissible residue levels have to be worked out as yet. Because of the large variation in soils types in Romania, it is necessary to work out soil specific norms at least for the large soil groups.

CONCLUSIONS

Shallow wells provide drinking water for the majority of the inhabitants of the NVZ communes, in particular those inhabiting the rural parts. Programs to develop piped water supply are underway, but will only be gradually implemented, and it may take several years before all villages will be equipped with safe public water supply.

Therefore in the monitoring plan, due attention should be given to the systematic assessment and consecutive monitoring of the water quality of these wells, starting with the public wells. Owners of private wells, in particular those with no or difficult access to public wells, should be offered the opportunity of a quality check free of charge or at an affordable cost.

Ideally the monitoring program should cover all the wells present in the NVZ communes. Due to the large number of wells (1404 localities scattered over 251 communes) it may not be possible to carry out systematic monitoring within a reasonable period of time or at an affordable cost. Therefore it is indicated to carefully select a strategic list of representative wells and to foresee a stepwise screening in order to ensure a maximum coverage within the shortest possible period of time.

Screening and monitoring of the drinking wells will be carried out using portable multiparameter probes allowing instant measurement and registration for a number of strategic parameters such as nitrate content, CEC and pH. In a later stage, where and when applicable, monitoring can be extended to comprehensive laboratory analyses for drinking water, including microbiological parameters or organic substances.

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