NUTRIENT LOAD FROM AGRICULTURAL SOURCES IN LOMBARDY (ITALY)

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ABSTRACT

The Lombardy region of Italy is characterized, from the agricultural point of view, by a high intensity of production and concentration of crops and livestock, mainly in the plains area. To improve the knowledge of potential impacts of agricultural activities on the environment, an assessment on loads of nutrients (nitrogen and phosphorus) deriving from agricultural practices has been carried out.

The evaluation is based on a mass balance of inputs and outputs at field level and considering phosphorous and nitrogen as potentially polluting nutrients. The inputs are therefore chemical and organic fertilisers; the outputs are the crop uptakes.

The results obtained have highlighted that the more risky areas are, as expected, those where there is a high livestock intensity. However, within these areas there is high variability according to the cropping system used and to the pedo-climatic conditions of the area. Nutrient surpluses are in some areas over 200 kg of nitrogen per hectare and 300 kg of phosphorus per hectare. Therefore it can be emphasised that there is a short term impact due to the high mobility of nitrogen. While the phosphorous excess does not have an obvious immediate impact, the consequent build up of P in soil might cause an increase of phosphorus release to surface water, and even to ground water under special circumstances.
Keywords: *Diffuse pollution, manure management, nutrient balance.*

INTRODUCTION

Agricultural activity has been often assumed to have the main responsibility for surface and ground water pollution that occurs from non-point sources. This consideration derives from the potential misuse of fertilisers, pesticides, slurry, manure, sludge, compost, as well as from certain agricultural practices. These are believed to contribute to an uncontrolled release of polluting substances, for example nitrogen and phosphorus, contained in those products.

For example, animal manure represents a valid source of fertilising substances, but its distribution is often in excess of crop nutrient requirements. Therefore, the surplus of nutrients entails a risk of nutrient emission towards air and surface and ground waters, causing environmental pollution.

Moreover, nutrient and other pollutant losses have a characteristically high variability in space and time, as they are strictly dependent on soil type, cropping system and rainfall pattern. In particular, the quantification of potential emissions, as a first approach, can be evaluated from the analysis of the agricultural production system used.

The difficulties related to the implementation of a consistent system designed to control the emissions from agriculture to the environment relate not only to the objective technical and managerial difficulties encountered in putting in practice the best available techniques, but also to the shortage of evidence on the effect that implementing these practices will have on emissions (Magette, 1998).

In fact, although there are a number of experiences that confirm the positive effect of some practices in reducing emissions in specific sites and in comparative terms, the extension of the results of these studies to a wider scale are still inadequate to obtain a clear quantitative correlation between practices and emissions.

Therefore, for the planning of technical and lawmaking actions aimed at the improvement of

water quality, it is necessary to use appropriate tools for the objective evaluation of pollution from non-point sources.

The increase of nutrient discharge towards water is fundamentally a consequence of imbalances between crop nutrient requirements and nutrients supply, although the effects are not easy to determine and cannot be generalised, as they depend on local conditions (pedology, topography, hydrology, management, etc.).

In brief, the risk of nutrient release can be considered proportional to the availability of nutrients in, or on, the soil in forms suitable to be transported towards waters.

MATERIALS AND METHODS

In order to assess the load of nutrients (nitrogen and phosphorus) deriving from agricultural practices in the Lombardy Region a methodology has been defined and applied.

For the aim of the evaluation at this scale, an evaluation of nutrient surpluses, representing a simplified form of mass balance, has been adopted. This simplification is, moreover, considered by the European Commission (2002) to be a good indicator of potential nutrient losses in the environment at farm, local or regional level.

Thus, here below the term "balance" will be utilised with this meaning and the procedure that can be used to carried out an evaluation based on the described principles will be analysed.

To evaluate the nutrient content in manure according to the different animal species bred, bibliographical data were adopted.

The computation of nitrogen (N) and phosphorus (P) supplied to the soil for each municipal district come from the following equation:

$$MS = \sum_{cat} nh_{cat} \cdot lw_{cat} \cdot up_{cat}$$

where: *MS* is the amount of nutrient for the municipal district;
cat is the category of animal;
nh is the number of animals of a particular category obtained from statistics;
lw is the live weight of the animals (average value);
up is the production of the nutrient for unit of live weight.

The amount of chemical fertilisers used, without credit for manure applications, were obtained from the current agronomic indications reported by different authors (Bonciarelli, 1980 and 1987; Baldoni et al., 1982; Manuale di Agricoltura, 1997; Tesi, 1987). Crop nutrient uptakes and average yields were obtained from the disciplinary measures for the application of integrated agricultural practices established by Lombardy Region in the framework of the Rural Development Scheme. Where necessary this information was integrated with other sources (Bonciarelli, 1980 and 1987; Baldoni et al., 1982; Manuale di Agricoltura, 1997; Tesi, 1987).

The calculation for the municipal district followed a methodology similar to the above described for other factors and considering the area involved in producing specific crops (from statistics), the average yield and the unitary nutrient uptake.

Determination of fertilising and uptake periods

For the purpose of this evaluation a monthly time scale was considered appropriate. With regard to manure utilisation, the average amount of fertiliser used for each district was obtained

from the analysis of the Nutrient Management Plan (NMP) submitted by farmers in compliance with Lombardy region environmental requirements. The database of NMP's refers to more than 7,000 livestock farms; and although not all the farms in the region are covered, the submitted NMP's are considered a representative sample of the behaviour of farmers in relation to the agricultural practices adopted in this region.

To obtain similar information related to chemical fertilisers, the suggested fertilisation practices were tabulated for the different crops. Finally, the nitrogen monthly uptakes by crops were established on the basis of the different crops behaviour reported in the cited literature. A similar analysis for the phosphorus uptake by crops was conducted, but on an annual time scale, as this nutrient cycle assure a more stable concentration of the element in the soil and therefore an annual time scale seemed to be adequate.

Determination of nutrient balance

The devised methodology considers an independent evaluation of the three factors of the balance described (manure fertilisers, chemical fertilisers, crop uptake) and a subsequent combination in order to obtain a simplified balance of nutrients and therefore, the surplus (or deficit).

In particular, the combination of chemical and organic fertilisers was obtained by the following equation:

$$A_{tot} = (F_{rich} - k_{org} \cdot F_{org}) + F_{org}$$

where:

A_{tot} : Total amount of nutrient supplied (kg) in each municipal district

F_{rich} : Total amount of nutrient required by the agricultural practice (kg)

k_{org} : Reduction coefficient used to consider the combination of organic and chemical fertiliser;

F_{org}: Amount of nutrient supplied with manure.

This equation takes into account that not all farms in a municipality have livestock, and thus the distribution of manure is performed only on a fraction of the agricultural land of the municipal district. Moreover, the current practice does not account for the full nutrient content of manure, with the consequence of an overlapping fertilisation by chemical and organic sources. The coefficient k_{org} varies from 0 to 1. The lower value corresponds to the limit situation when manure fertilisation is not considered at all, and therefore the total nutrient supply is equivalent to the customary recommended chemical fertilisation rate plus the nutrient produced from livestock in the district area.

The upper value of 1, on the contrary, means the best utilisation of manure without any overlapping with chemical fertilisers.

RESULTS

On the basis of these considerations, and on the basis of the previous experiences carried out, the value of the coefficient korg has been set for the subsequent processing at a value of 0.4.

The balance for each municipal district has been then obtained as the difference between the total supply (A_{tot}) and the total crop uptake. A positive value of this difference means a surplus of nutrients that are potentially available for transport to water, but that are not necessarily lost (figure 1).

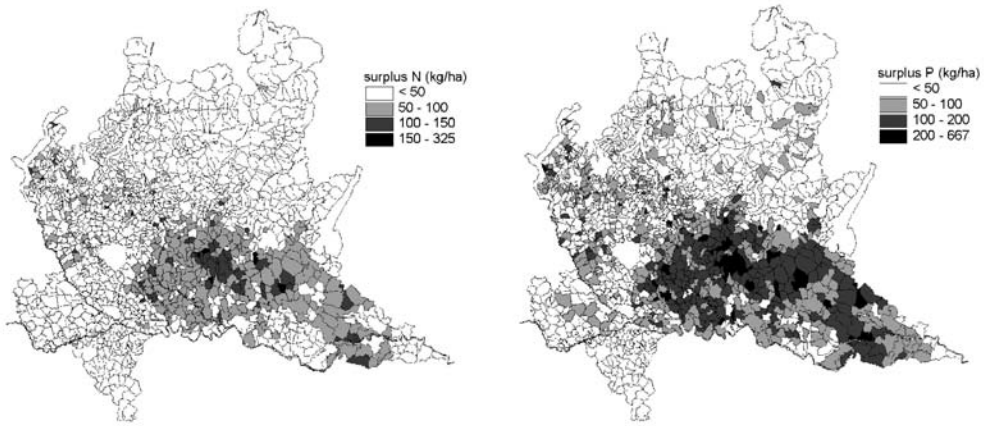

Figure 1 *- Annual surplus of nutrients in the Lombardy Region at municipal district level.*

CONCLUSIONS

The described methodology for evaluating the nutrient amounts potentially available for transport from agricultural land to water has been adopted for the assessment of non-point pollution from agriculture in the framework of the water protection scheme in Lombardy Region. It has to be emphasised how this methodology can be used for other purposes, but with special care to the type and quality of available data. Data availability is often the real limiting factor in this type of assessment. In fact, the simplification of the complex interactions in the nutrient cycles is always based on the availability of data. Nevertheless, the application of the described methodology can be considered only as a first assessment of the nutrient surplus as a means mainly to identify the more critical areas on which to focus actions oriented to a better understanding of the influence of agricultural activity on non-point source pollution (water quality monitoring, collection of data on agricultural practices, etc.).

Only with high quality, detailed datasets that will be gathered from such focussed studies, will it be possible to apply more comprehensive models for the evaluation of nutrient surpluses and as a consequence, their losses to surface and ground water.

REFERENCES

Baldoni, R., Giardini, L. 1982. Coltivazioni erbacee. Pàtron Editore, Bologna.

Bonciarelli, F. 1980. Agronomia. Edagricole, Bologna.

Bonciarelli, F. 1987. Coltivazioni erbacee da pieno campo. Edagricole, Bologna.

European Commission. 2002. Implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources. Office for Official Publications of the European Communities, Luxembourg.

Magette, W. L. 1998. Factors Affecting Losses of Nutrients from Agricultural Systems and Delivery to Water Resources. Draft guidelines for nutrient use in agricultural enterprises, Teagasc, Wexford, Ireland.

Magette, W.L. 1991. "Protecting your water supply", Water Resource Information, n. 20, University Manuale di Agricoltura. 1997. Hoepli, Milano.

Tesi, R. 1987. "Principi di orticoltura", Edagricole, Bologna.