

Toward an ecological agriculture on well catchment areas: what impacts in terms of nitric pollution at the scale of the Seine watershed, France?

Vers une agriculture écologique sur les bassins d'alimentation de captage : quels impacts en termes de contamination nitrique à l'échelle du bassin de la Seine, France ?

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RÉSUMÉ

L'eutrophisation des hydrosystèmes continentaux et des zones côtières adjacentes est un des défis environnementaux majeurs de ce début de 21^{ème} siècle. En Europe Occidentale, l'eutrophisation a commencé au début des années 1950 au moment de la généralisation de l'emploi d'engrais synthétiques. Les politiques et les citoyens sont conscients du problème depuis les années 1970 et le « Grenelle de l'Environnement » est une des dernières mesures adoptée en France en 2007. Ce corpus de lois a pour but d'atteindre le bon état écologique des captages d'eau potable. Différents moyens peuvent être mis en œuvre : reforestation ou conversion de 20 % des terres arables des bassins d'alimentation de captage en une agriculture utilisant moins d'engrais synthétiques (agriculture intégrée, agriculture biologique ...). Dans cette étude un scénario idéalisé, dans lequel la totalité des terres arables situées dans les bassins d'alimentation de captage ont été converties en agriculture biologique, a été testé.

ABSTRACT

Eutrophication of continental hydrosystems and adjacent coastal marine zones is one of the most challenging environmental issues of this beginning of the 21st century. In Western Europe, eutrophication began to be an environmental issue in the 50's due to the generalization of application of synthetic fertilizers. Policies and citizens are aware of the problem since the seventies, and one of the last measures adopted in 2007 in France is called the "Grenelle de l'Environnement". This corpus of laws aims to achieve a good ecological status in the wells devoted to drinking water supply. Different means may be implemented: reforestation or conversion of 20 % of the arable lands within the well catchment areas (WCA) toward an agriculture using less or no synthetic fertilizers. In this study an idealized scenario converting 100 % of the arable lands of the WCA into organic farming was built.

MOTS CLES

Eutrophication, nitrate contamination, organic farming, Seine River basin, well catchment area.

1 PROBLEM AND APPROACH

1.1 Introduction

Eutrophication of continental hydrosystems and adjacent coastal marine zones is one of the most challenging environmental issues of this beginning of the 21st century. Eutrophication is a threat for producing drinking water, for aquatic biodiversity and for touristic activities at the coastal zone. The opening of biogeochemical cycles, especially nitrogen (N) and phosphorus (P) cycles, is at the origin of the imbalanced ratios N:P:Si. This imbalance leads to the proliferation of non siliceous algae as mucilaginous *Phaeocystis* or toxic *Dinophysis*, because they are not easily grazed by higher organisms. When these algae decay, this organic matter is mineralized by bacteria which deplete dissolved oxygen of the water column leading to hypoxia or anoxia.

1.2 Study site

The Seine watershed is located in the northern part of France and covers 76 270 km². The Parisian agglomeration, the fourth of Europe in terms of population (12 000 000 inh.), is located at the centre of the basin. Arable lands cover about 50 % of the watershed and are devoted to intensive crop production. Application of synthetic fertilizers is at the origin of the aquifer contamination (more than the limit of 11.3 mgN.l⁻¹ = 50 mgNO₃/l within the Champigny aquifer).

2 METHOD

2.1 The modelling approach

Nutrients cycling are modelled using the Seneque/Riverstrahler model (SR model) (Ruelland et al, 2007). The SR model takes into account both point and diffuse sources. Point sources are industrial wastewaters and domestic wastewater discharged from treatment plants (WWTP), characterized by a load in terms of equivalent inhabitants and by a corresponding kind of treatment. Diffuse sources are defined according to land use and agricultural practices (Thieu et al, 2009). For each sector of the drainage basin considered, a mean constant concentration is provided for sub-root water and groundwater concentrations respectively, which are derived from the calculation of agricultural N surpluses based on agricultural statistics.

2.2 An ecological agriculture on well catchment areas

One mean to achieve the goal promoted by the “Grenelle” is to implement an agriculture using less or no synthetic fertilizers on well catchment areas. The determination of well catchment areas by water agencies is still in progress; nevertheless we developed a method to determine them.

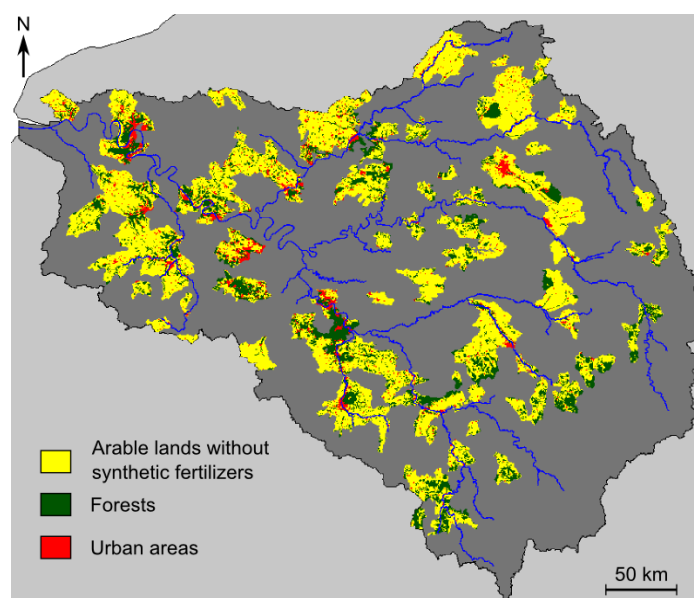


Figure 1: Well catchment areas and arable lands without synthetic fertilizers (in yellow)

According to this method, well catchment areas represent about a third of the total area of the Seine watershed (Fig. 1), a value in coherence with the estimation of the Seine Normandy Water Agency. Values of NO_3 concentrations of sub-root water corresponding to organic farming were applied to all arable lands within these well catchment areas, according the method developed by Thieu et al (Thieu et al, 2010).

3 RESULTS

Comparison, at the outlet of the Seine (Poses), between the reference situation of 2006 and the modelling of the implementation of the organic farming scenario is shown on figure 2. Nitrate concentration decreases by about 2 mgN.l^{-1} in winter and by less 1 mgN.l^{-1} in summer. The annual mean decrease is about 1.5 mgN.l^{-1} .

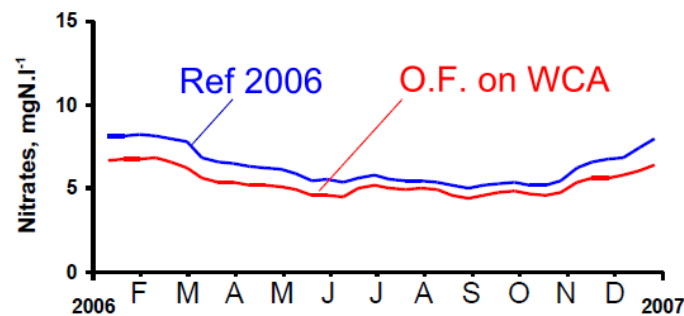


Figure 2: Comparison of NO_3 concentrations at Poses between the reference year 2006 (red line) and the modelling of the implementation of organic agriculture (blue line)

To go further, definition of well catchment areas are expected from the water agencies, and more studies about NO_3 concentration in sub-root water in new farming practice context are needed.

4 CONCLUSION

According to these results, the “Grenelle de l’Environnement” corpus of laws seems to be not sufficient to decrease NO_3 concentration at the outlet of the Seine River to re-equilibrate the nutrient stoichiometry. Consequently, to reach such an objective, this approach should be completed by other ones, as extension of ecological farming or reintroduction of a more retentive landscape.

LIST OF REFERENCES

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