Pan-European assessment of environmental legislation and alternatives options to mitigate nutrients (N, P) contamination from rivers to coastal seas

Etat des lieux Européen de la contamination par les nutriments (N, P) des fleuves aux zones côtières. Impact des réglementations et autres mesures environnementales

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RÉSUMÉ

L'application continentale du modèle semi-distribué GREEN a permis de mettre en relation l'anthropisation des bassins versants et les flux de nutriments exportés vers les zones côtières Européennes. Une évaluation de l'impact potentiel des futures réglementations environnementales est proposée à l'échéance de 2020. Cette analyse souligne des différences significatives entre les différentes régions européennes, et met l'accent sur l'importance des conditions hydrologiques dans le cadre d'une estimation des flux de nutriments à long terme. Cette analyse prospective intègre un scenario de *status quo*, une application stricte des mesures environnementales en cours d'implémentation, une consommation réduite des protéines animales dans le régime alimentaire européen et une meilleure gestion des effluents d'élevage. Cette évaluation est conduite à l'échelle continentale et propose d'estimer d'une part l'atténuation des émissions d'origine anthropique et d'autre part l'impact sur les quantités de nutriments exportés vers les zones côtières.

ABSTRACT

A spatially explicit statistical approach (GREEN model) applied to continental Europe on a sub-catchment basis, is used to link input from anthropogenic activities and nutrient loads into European Seas (namely nitrogen and phosphorous). Effectiveness of environmental legislation is assessed at the horizon 2020, emphasizing the regional differences between European countries as well as the respective contribution of anthropogenic changes and hydrological fluctuation in nutrient exports. The set of scenarios analyzed includes a business as usual situation, a full implementation of on going policy options, a change in European diet based on a strong reduction of meat intake, and optimized management of agricultural practices. All prospective analyses are implemented for EU-27 and are discussed in terms of capacities to mitigate land based emissions of nutrient, and also according to their impacts on the loads of nutrient exported to European coastal areas.

KEYWORDS

Europe, GREEN model, Nitrogen, Phosphorous, Policy, Scenarios analyses.

1 INTRODUCTION

Eutrophication has been an acute problem in Europe waters for about two decades, and cases of severe eutrophication are still observed even after implementation of environmental legislations since the beginning of the '90s to control nutrient losses and inputs in the environment.

The persistence of these riverine alteration syndromes attests for the difficulty to reverse the increasing human pressures in European watersheds and calls for long term assessment. In order to support the implementation of the Marine Strategy Directive, a long term analysis of land-based nutrient loads in European Seas is performed based on the GREEN modelling approach.

2 METHODS

2.1 The GREEN model and European databases

The GREEN (Geospatial Regression Equation for European Nutrient losses) model consists of a regression equation based on spatially referenced input data. It contains a simplified representation of the processes of nutrient (nitrogen and phosphorus) transport and retention in the river basin and a spatial representation of the various nutrient sources and physical characteristics that influence the nutrient transformations and losses. The GREEN model considers diffuse sources that include fertilizers (artificial and manure), atmospheric deposition, and scattered dwellings, are first reduced in the soil and then partially retained in the streams. Then point sources, which include discharges from sewers, wastewater treatment plants, industries, and paved areas, are retained only in the streams.

Achievement of such a modelling approach for the whole continental Europe was supported by development of a EU wide environmental database including features related to climate, nutrient pressure, river basin morphology and capable of supporting the implementation of the GREEN model on a sub-catchment basis.

2.2 Storylines of the scenarios

Assessments of prospective changes in nutrient emission systematically refer to a base line situation that includes change in population count and distribution and considers a status-quo in wastewater treatment.

A first scenario simulates a full implementation of the Urban Waste Water Treatment Directive (Directive 91/271/EEC) based on a set of conditions and contingencies, including the size of municipalities and the sensitivity of receiving area, and required waste water discharged to undergo appropriate treatments.

An additional scenario targeting point sources tests a ban of phosphates and others phosphorus compounds in household laundry detergent following the Commission proposal COM (2010) 597.

A third scenario includes prospective changes in human food consumption following the recommendations made by the World Cancer Research Fund for a healthier diet. They go beyond the strict framework of the ongoing changes planned by European policy, and consider adaptation of agricultural land to support a human diet with less meat, more fruits and vegetables.

A last scenario, intends to improve nutrient supply in Europe based on an optimal reuse of animal manure and the adjustment of minimized mineral inputs. It emphasizes the possibility of redistributing the manure locally produced, according to the demand for both N and P in surrounding areas.

3 RESULTS AND DISCUSSION

3.1 Calibration of the GREEN model

The model calibration was performed for about 1200 monitoring points covering a period extending from 1985 to 2005 and yielded results in good agreement with the measured data, both for the total nitrogen and the total phosphorus loads. For the period 1985–2005, the coefficient of efficiency of calibration was 92% for the nitrogen model and 71% for the phosphorus model, with yearly efficiencies ranging from 76% to 97% for nitrogen, and from 50% to 87% for phosphorus. For both nutrients, the comparison between measured and estimated loads did not show any significant systematic or temporal deviations, which indicates the model's robustness (Grizzetti et al 2011).

3.2 Assessment of nutrients mitigation measures at the horizon 2020

An increase of both nitrogen and phosphorus land based emissions is estimated from 2005 to 2020 for the whole Europe following a business as usual scenario. For EU27, total nitrogen inputs will increase from 22,900 kt/yr to 24,350 kt/yr, while changes in phosphorus inputs are less important with an increase from 3,500 kt/yr to 3,650 kt/yr.

Mitigation of nutrients point sources by improving wastewater treatment is generally presented as an end-of-pipe option, but it is clearly the most effective way to decrease both nitrogen and phosphorus exported to the sea. However, the benefits of a progressive improvement in wastewater treatment plants removal could be compensated by an important transfer of nutrient loads from scatter-dwelling emission (uncollected) to point source (collected). For this reason a full implementation of the UWWD leads to a contrasted assessment in Europe.

Interestingly enough, changing European diet by decreasing beef and pork meats consumption and an increase of vegetal proteins, have a low impact on nitrogen and phosphorus diffuse sources. Indeed, it is shown that the production of meat in Europe will be essentially preserved due to a large increase of meat export towards other countries.

Finally, without forecasting drastic changes in human consumption and agricultural practices, a better re-use of animal manure produced at the basin scale is the most efficient option tested. This scenario also emphasizes a significant decrease in the application of mineral nitrogen, with evident benefits also due to the continuously increasing price of nitrogen fertilisers.

4 CONCLUSION

The development of a consistent set of scenarios raises the issue of the scale of the analysis. Local scale analyses are generally more reliable, but are unable to take into account regional dynamics and could not be transposed to a broader regional context. Only large scale assessments can address this issue, and the GREEN model has demonstrated its relevance for that purpose. In this prospective exercise, it has enabled to integrate the local impact of human activities in watersheds and also the societal and economic drivers acting at a higher scale. In particular, this study suggests that analysing the environmental impact of change in human diet should further consider both agricultural production and global trade. The use of such model is undeniably a major asset for supporting future European regulations

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