Spatial characterization of reactive N flows in the agro-food system of a semiarid Mediterranean region

Marta Moro[1], Luis Lassaletta[1], Miguel Quemada[1], Antonio Vallejo[1], Margarita-Ruíz Ramos[1], Alfredo Rodríguez[1,2], and Alberto Sanz-Cobeña[1*]

[1] ETSI Agronómica, Alimentaria y de Biosistemas, Centro de Estudios e Investigación para la Gestión de Riesgos Agrarios y Medioambientales (CEIGRAM), Universidad Politécnica de Madrid, Ciudad Universitaria s/n, 28040, Madrid, Spain
[2] Department of Economic Analysis and Finances, Universidad de Castilla-La Mancha, 45071, Toledo, Spain

*E-mail: a.sanz@upm.es

Abstract

This work aims to show the possibility of increasing nitrogen (N) use efficiency of the agro-food system of one region within the most important vegetables production areas in Southern EU. Following spatialization of N flows in this Mediterranean agricultural region, an integrated scenario analysis was performed aiming to propose effective reactive N (N_r) abatement options while being sensitive to maintenance of crop yields. Our results showed that intensive crop production, mainly under irrigation, and the disconnection of crop and livestock production systems is shaping this agro-food system. High N surplus were estimated in several areas thus enhancing the risk of N_r losses to the environment. Implementation of technical abatement strategies such as manure incorporation would significantly abate N_r losses mainly in the form of NH_3 while increasing crop yields. Implementation of this strategy may increase N surplus thus triggering the risk of pollution swapping.

Keywords: agro-food system, N surplus, ammonia, abatement strategies, Mediterranean agriculture.

1. Introduction

Intensive use of nitrogen (N) within the agro-food system, exemplified in excessive fertilization and increasing production of animal manures in several regions worldwide, has triggered a disruption in the natural N cycle leading to significant losses of this nutrient to the environment and severe associated environmental impacts (Springman et al., 2018). An effective characterization of N pathways in regional agro-food systems, highlighting hotspots of reactive N (N_r) release, is crucial for a proper design of effective N_r abatement strategies. With the present work we aimed to characterize the main N flows in the agro-food system of one the most relevant agricultural areas in Southern EU, the Murcia region. Additionally, several N_r abatement scenarios were assessed in an integrated way (i.e. considering impacts on different pathways of N loss and crop yields).

2. Materials and methods

The Generic Representation of the Agro-food System approach (Billen et al., 2018) was used to characterize main N pathways in the Murcia agro-food system, then, a spatialization of N flows was performed using Corine Land Cover. This approach allowed to identify and spatialize hotspots where the implementation of abatement strategies is imperative. As a final step, several NH_3 mitigation strategies were assessed in a regional basis following the integrated scenario analysis proposed by Sanz-Cobena et al. (2014), with special focus on potential pollution swapping implications in the form of (e.g.) N surplus, as a proxy of NO_3^- leaching, and N_2O emissions.

3. Results and discussion

The agro-food system in the Murcia Region is characterized by high N surplus in several areas thus enhancing the risk of N_r losses to the environment (Fig. 1), in the form of (e.g.) N_2O, NH_3 to the atmosphere and leached NO_3^- to water bodies. There is also a spatial concentration of hot spots, coinciding with the most intensive crops in the Region (outdoor and indoor horticultural crops, citrus and other irrigated orchards).

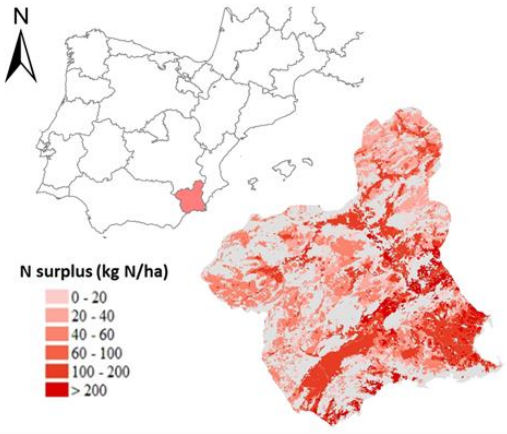

Fig. 1. Location of Murcia Region (upper side) and the estimated distribution of N surplus in the Region (bottom).

There are several reasons behind high N surpluses. Firstly, a large disconnection between crop and livestock systems, which involves the entry of a significant amount of nitrogen in the form of feed (Fig. 2), which is then transformed onto high amounts of N enriched manure, difficult to be efficiently managed. And secondly, an excessive use of synthetic N fertilizers together with a dominant dry climate enhances the need of irrigation for such an intensive production, which in turn, triggers soil processes controlling the release of N_r. All this in a context of globalization with an increasing towards a diet richer in animal protein, associated with higher crop yields for both local consumption and export.

Agronomic and technological NH_3 mitigation techniques have been also evaluated here. These include the incorporation of organic fertilization, the use of urease inhibitors and the avoidance of urea fertilization. These NH_3 abatement measures could have two possible agro-environmental side-effects.

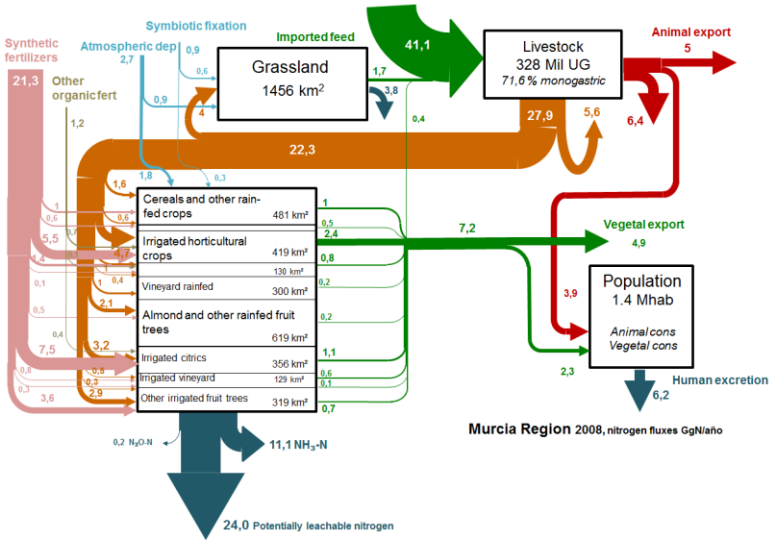

Fig. 2. Generic representation of the agro-food system in the Region of Murcia (Spain)

On one hand, a possibility of increasing crop yields by having more N_r available in soil, and, on the other hand, an adverse effect over environmental sustainability linked to N_r suitable to be lost (i.e. pollution swapping). Our results showed that NH_3 emissions can be reduced by up to 91% by manure incorporation, while obtaining an average increase in crop yields of 22%.

Acknowledgements

Authors are grateful to the Comunidad de Madrid (Spain) and Structural Funds 2014-2020 (ERDF and ESF) for the financial support (project AGRISOST-CM S2018/BAA-4330) as well as MACSUR-JPI and the research coordinated program of IAEA-FAO (CRP D1.5016). L. Lassaletta (MINECO: RYC-2016-20269) and UPM-PP.

References

Billen G, Le Noë J, Garnier J 2018. Two contrasted future scenarios for the French agrofood system. *Sci. Total Environ.* 637–638, 695–705.

Sanz-Cobena A, Lassaletta L, Estellés F, Del Prado A, et al 2014. Yield-scaled mitigation of ammonia emission from N fertilization: the Spanish case. *Environ. Res. Lett.* 9, 125005.

Springmann M, Clark M, Mason-D'Croz D, Wiebe K, Bodirsky BL, Lassaletta L, de Vries W, et al 2018 Options for keeping the food system within environmental limits. *Nature* 562, 519-525.