Catherine Hénault
Directrice de Recherches INRAE - Coordinatrice du projet *NatAdGES (https://www6.inrae.fr/natadges).*
UMR Agroécologie - 17 rue Sully - 21065 Dijon cedex – France
catherine.henault@inrae.fr - 33 (0)6 42 58 51 22

Multi-scale spatialisation of N_2O emissions by soils and their mitigation potential in the Bourgogne Franche-Comté Region: advantages, limits and paths of exploitation for aiding decisions in the framework of ecological transition at local-regional scales

Alkassem-Alosman M.(1), François S.(2), Thiam S.(3), Saby N.P.A.(4), Rousset, C.(1), Hénault C.(1), de Sède-Marceau M.H.(5)

(1) Agroécologie, INRAE, Institut Agro, Univ. Bourgogne, Univ. Bourgogne Franche-Comté, F-21000 Dijon, France
(2) Atmo Bourgogne Franche-Comté, 37 rue Battant, 25000 Besançon, France
(3) IAD - Territoire Digital, 11B rue Christian Huygens, 25000 Besançon, France
(4) INFOSOL, US1106, INRAE, 45075 Orléans, France
(5) Laboratoire ThéMA, UMR 6049, CNRS et Université de Bourgogne Franche-Comté, France

The French inventory of anthropic greenhouse gas (GHG) emissions estimates that emissions by fertilised soils contribute 42% of the N_2O (nitrous oxide) emitted by the agricultural sector, i.e., 8% of total national emissions *[1]*. As N_2O has a global warming potential about 300 times that of carbon dioxide (CO_2), the assessment of emission potentials and/or reduction of this gas seems essential when defining and implementing policies aimed at reaching the reduction objectives set at international, national and regional levels.

To estimate N_2O emissions by soils, three inventory methods, with increasing requirements (Tier 1, 2 or 3), are now used according to the recommendations of the IPCC. The method of level 1 takes into account only the quantity of nitrogen (mineral and organic) contributed to the field to which is applied one *[2]* or more emission coefficients *[3]*, as proposed in the methodology of *Label Bas Carbone en Grandes Cultures en France* (Low Carbon Label of Major Crops in France) *[4]*. The methods of level 2 adapt emission factors by country on the basis of local references. The method of level 3 employs mechanistic emission models. Furthermore, recent works have highlighted the predominant role of soil pH in the intensity of soil N_2O emissions. They have therefore opened the path to reducing N_2O emissions by managing soil pH, associated with calculations of mitigation potentials by utilising this lever *[5]*.

To quantify N_2O emissions by soils in Bourgogne Franche-Comté, and their mitigation potential, we applied the Tier 1 methodology *sensu stricto*, the Low Carbon Label in Major Crops in France methodology and two models of Tier 2 (*[6]*; *[7]*), using different sources of spatial data dealing with soil, climate and crop. In particular, we compared 3 sources of data for the soil properties available on the study area; BDAT, LUCAS maps and IGCS *[8,9,10,11,12]*. We therefore estimated an average value of N_2O emissions by soils receiving an annual rainfall less than 950 mm in Bourgogne of 2150 t N-N_2O year^{-1}, between 1800 and 5000 t N-N_2O year^{-1}, according to the databases and calculation methods used (figure 1). Although the Tier 1 methodology applied strictly did not allow forecasting a reduction of N_2O emissions by acid soils following the input of liming materials, the other calculations performed permitted estimating on average a mitigation of N_2O emissions of 20% in the region of study, ranging from 6 to 40% (figure 1).

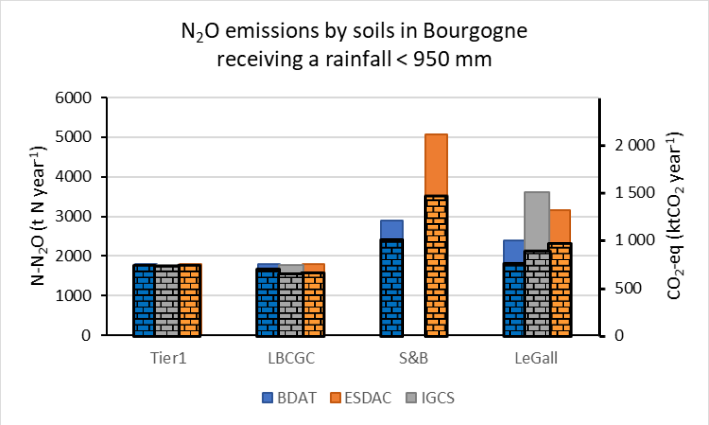

Figure 1: Estimation of N_2O emissions by soils in Bourgogne receiving a rainfall < 950 mm under the conditions of 2018 and after theoretical liming of acid soils .

These estimations were performed with different sources of soil data (BDAT, Lucas Soil, IGCS) and different calculation methodologies.

Tier 1: calculations performed according to the Tier 1

LBLGC: calculations performed according to the methodology proposed by the Low Carbon Label of Major Crops in France Methodology.

S&B: calculations performed according to *[7].*

Le Gall: calculations according to *[6].*

Since the calculations were performed spatially, they permit identifying areas of interest in relation to the use of liming acid soils to reduce soil N_2O emissions. In our case study, these areas are mainly Morvan, the Bresse depression and the Yonne valley. In these areas, the mitigation potential can exceed 50%.

In addition to their formatting for a scientific publication, we are working on the dissemination of these results to political decision-makers so that they are taken into account for the development of a National Low Carbon Strategy in France *[13]*. To achieve this, we are currently developing the "agriculture" sheet of the regional observation, analysis and air-energy-climate platform, Opteer *[14]*, to facilitate the implantation of quantifiable biotechnical solutions to reduce GHG emissions that can be used by political decision-makers. This entire approach can be transferred to other regions in France and abroad.

This study was carried out in the framework of the *NatAdGES* project, supported by the investments in the future programme, project ISITE-BFC (contract ANR-15-IDEX-0003), the FEDER, BPI France and CMI-Roullier.

[1] Citepa, juillet 2021. Rapport n°1789sec / 2021 | Secten_juillet2021.docx.

[2] GIEC., 2006. Volume 4 Chapitre 11. In: Eggleston HS, Buendia L, Miwa K, Ngara T, Tanabe K (Eds)

[3] Hergoualc'h, K., Akiyama, H., Bernoux, M., et al.. (2019).Volume 4 Chapter 11. In E. Calvo Buendia, K. Tanabe, A. Kranjc, et al. (Eds.), Intergovernmental Panel on Climate Change.

[4] Soenen B., Henaff M., Lagrange H., Lanckriet E., Schneider A., Duval R., Streibig J.L. 2021. Méthode Label Bas-Carbone Grandes Cultures (version 1.0). 133p. Ce document est disponible sur le site du MTE (https://www.ecologie.gouv.fr/label-bas-carbone)

[5] Hénault, C., Bourennane, H., Ayzac, A. et al., 2019. Sci Rep 9, 20182. https://doi.org/10.1038/s41598-019-56694-3

[6] Le Gall, C., Cellier, P., Hénault, C. 2016. Empreinte carbone: évaluer et agir. Partie I -, p27-51.

[7] Stehfest. E, Bouwman. L, 2006. Nutr. Cycl. Agroecosystems. 74, 207–228.

[8] Lemercier et al., 2014. Etude et Gestion des Sols. 21. 141-150 (https://doi.org/10.15454/NFQRRB).

[9] Ballabio C., Panagos P., Montanarella L., 2016. Geoderma, 261 , pp. 110-123 (https://doi.org/10.1016/j.geoderma.2015.07.006.

[10] Chretien J et Laroche B., 2006. L'inventaire des sols de Bourgogne, Rev. sci. Bourgogne-Nature 4-2006, 18-20.

[11] Martin, P., Rabenandrasana, N.et al. 2021, RPG Explorer Crop successions France 2007-2014, 2007-2019, 2015-2019, Portail Data INRAE, V2, UNF:6:WJbvCafksh00/+PmNl2Zcg https://doi.org/10.15454/XH84QB,

[12] Lémond J., 2010. Le projet DRIAS : premières études et documents ; CNRM / GAME, Météo-France, CNRS ; Direction de la Climatologie. Réunion Comité Utilisateurs, le 29 juin 2010. http://www.drias-climat.fr/ref

[13] https://www.ecologie.gouv.fr/sites/default/files/2020-03-25_MTES_SNBC2.pdf

[14] De Sède-Marceau M-H., François S, Pauc B., 2018. Numéro spécial de la Revue Internationale de Géomatique Janvier-Mars 2018, Vol 28, n°1, pp 95-124