

PHD PROPOSAL FOR THE DOCTORAL SCHOOL « Ecologie, Géosciences, Agronomie, ALimentation »

GENERAL INFORMATION

Thesis title: Agronomical and Climatic Determinants of the C, N and P dissolved fluxes. Effects of the vegetative cover and the supply of methanisation digestates.
Acronym: GALILEO
Disciplinary field 1: Geosciences Disciplinary field 2: Agronomy
Three keywords: soil, organic waste product, water quality, carbon storage, coupling of biogeochemical cycles.
Research unit : Geosciences Rennes – UMR6118
Name of the thesis director: Gérard Gruau Email address of the thesis director : gerard.gruau@univ-rennes1.fr Name of the thesis co-supervisor 1 (if applicable): Emilie Jardé Email address of the thesis co-supervisor 1 (if applicable): emilie.jarde@univ-rennes1.fr Name of the thesis co-supervisor 2 (if applicable): Anne Jaffrezic Email address of the thesis co-supervisor 2 (if applicable): anne.jaffrezic@agrocampus-ouest.fr
Thesis grant (funding origin and amount): ADEME SOERE EFELE project
Contact(s) (mailing address and E-mail):
Recruitment process: Recruitment process depends on thesis funding. To select the corresponding recruitment process, please visit the EGAAL website here . This information is needed for proposal publication. <input checked="" type="checkbox"/> Doctoral school contest <input type="checkbox"/> Interview <input type="checkbox"/> Other (indicate) :

All sections must be filled. Once filled, please save the proposal form in pdf format using the following naming: Supervisor Name_Unit_Subject Acronym_EN.pdf

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SCIENTIFIC DESCRIPTION OF THE PhD PROJECT

Socio-economic and scientific context : (10 lines)

Several levers can be implemented to manage biogeochemical cycles more sustainably as part of the agro-ecological transition. In the context of livestock polyculture, these levers are mainly (i) improving the recycling of nitrogen (N) and phosphorus (P) nutrients through better agronomic recovery of organic waste products (ORP), (ii) introducing multiservice intermediate cover to reduce nitrate leaching, store carbon (C), limit erosion, and reduce the use of herbicides, and (iii) modifying tillage (shallow or simplified tillage) to reduce the use of fossil fuels. Methanisation is also a lever for the energy recovery of PROs and for reducing the impact of agriculture on climate change. The recycling of transformed products, compost or digestates from methanisation, improves the physical properties of soils in the short and long term. On the other hand, the effect of inputs of these PROs on losses of dissolved organic carbon (DOC) and dissolved P (P_{diss}) is poorly documented and remains an important scientific lock in polyculture-livestock farming systems, although these elements play a determining role in eutrophication processes and pollutant transport and impact the health of continental and coastal aquatic ecosystems (Bol et al., 2018). The results of this project will contribute to providing benchmarks for the assessment of the ecosystem service of water quality. But they can also be used to assess carbon storage in deep soil horizons. Indeed, deep DOC transfers that do not reach the water table can be evaluated positively as they contribute to carbon storage in soils and increase the climate regulation service.

Assumptions and questions (8 lines) The objectives of this thesis project are i) to describe and analyze the interactions between C, N and P cycles in the framework of the valorisation of farm effluent digestate in lysimetric devices, ii) to know the processes related to key stages of the cycles; biodegradation and stabilization of organic compounds, nutrient availability for crops and quantification of dissolved C, N and P emissions. We will study the seasonal variations of the stoichiometric ratios C, N P in solution. The thesis will be based on chronicles of leachate quality measurement acquired over 10 years on the EFELE device with the digestate input modality compared to the reference untreated slurry. These general objectives are declined through the research questions below:

- What is the interannual balance (10 years) of C and P flows stored in the deep soil horizons and emitted towards the aquatic environment (groundwater) for the valorization of a slurry digestate compared to reference fertilization (mineral, slurry, manure, compost)?
- Are the COD and P (organic and mineral) fluxes in mineral horizons controlled by the initial composition of the digestion digestates?
- What is the role of cover, PRO type and climate in the synchrony/asynchrony of dissolved C, N and P and the control of fluxes to deep horizons or groundwater?

The main steps of the thesis and scientific procedure (10-12 lines)

This project is first based on the EFELE lysimetric device of SOERE PRO by mobilizing the data already acquired (2014-2021) for the dissolved C, N and PO₄ elements and the analyses that will be acquired during the thesis (2021-2024) which will include the dissolved organic P.

The first step consists in the quantification of the dissolved NOC budgets and the interpretation of the correlations between elements. The climatic and agronomic determinants (winter cover and type of pro) controlling the fluxes will be studied by a statistical approach.

The second step is the realization of the experiment in controlled conditions of the effect of the composition of the methanation digestate on the fluxes, the molecular composition of the MODs and the CNP stoichiometry in solution.

The third step is to study the soil-plant interaction to understand the processes that control the presence/absence of nitrate, COD and PO₄ in the soil solution by focusing on the rhizosphere since the cover seems to mobilize a more or less leachable pool of soil.

The last step will be the study of data acquired in another pedoclimatic context on the same soil and similar PROs but with a focus on mineral/manure (Canada). The approach will be to study the agronomic and climatic determinants of i) the interannual variability of dissolved fluxes, ii) the intra-annual variability of fluxes and concentrations of DOC, NO₃, PO₄ and stoichiometric ratios C,N,P in solution at 40 cm.

Methodological and technical approaches considered (4-6 lines)

This project is first based on the EFELE lysimetric device of SOERE PRO by mobilizing the data already acquired (2014-2021) for the dissolved C, N and PO₄ elements and the analyses that will be acquired during the thesis (2021-2024) which will include the dissolved organic P. The molecular composition of dissolved organic matter (DOM) will be studied by thermochemolysis coupled with a gas chromatograph and a mass spectrometer. This method allows the identification of about a hundred target molecules belonging to the families of lignins and tannins (plant origin), polysaccharides (plant and microbial origin), cutins and suberins (plant origin) and phospholipidic fatty acids (microbial origin). The study of the biogeochemistry of MOD via this method is a recognized know-how developed at Géosciences Rennes. The MOD of the leachates have been characterized by spectrophotometric methods (UV and 3D fluorescence) since 2014. These measurements, in addition to biodegradability tests, will help to assess the reactivity of dissolved organic matter. In addition, we will carry out controlled experiments on smaller lysimeters, from the lysimetric device of the Apivale GIS. These open lysimeters will allow i) to study more finely the rhizosphere and the pH and nutrient gradients under cover of wheat and mustard ii) to test several types of digestates.

Scientific and technical skills required by the candidate

The project is at the interface of several disciplines (soil sciences, biogeochemistry, analytical chemistry, environmental chemistry, geosciences, agronomy). It requires skills in data processing (statistics) and the implementation of chemical analysis in the laboratory for the characterization of the composition of dissolved organic matter. A first experience in modeling will be a plus.

THESIS SUPERVISION¹

Unit name: UMR 6118 Géosciences Rennes	Team name: DIMENV
Unit director name: Olivier Dauteuil	Team director name: Yves Méheust
Mailing address of the unit director: Olivier.dauteuil@univ-rennes1.fr	Mailing address of the team director: Yves.meheust@univ-rennes1.fr
Thesis director Surname, first name: Gruau Gérard Position: CNRS research director Obtained date of the HDR (Habilitation thesis to supervise research): 1993 Employer: CNRS Doctoral school affiliation: Rate of thesis supervision in the present project (%):40% Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%): Number of current thesis supervisions/co-supervisions: 0	
Thesis co-supervisor 1 (if applicable) Surname, first name: Emilie Jardé	

¹ In EGAAL Doctoral School, if only one scientist in thesis supervision = 100% of supervision rate; if 2 people involved in thesis supervision = from 50% to 70% of supervision rate for the director; if 3 people involved in thesis supervision = 40% / 30% / 30% of supervision rate distribution among supervisors.

Position: CNRS researcher

Habilitation thesis to supervise research yes no If yes, date diploma received:

Employer: CNRS

Doctoral school affiliation: EGAAL

Rate of thesis supervision in the present project (%):30 %

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions: 0

Thesis co-supervisor 2 (if applicable)

Surname, first name: Jaffrezic Anne

Position: Lecturer

Habilitation thesis to supervise research yes no If yes, date diploma received: 2018

Employer: Agrocampus Ouest

Doctoral school affiliation: EGAAL

Rate of thesis supervision in the present project (%):30 %

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions:

Private partner (if CIFRE funding, private funding,...)

Surname, first name:

Position:

Employer:

Rate of thesis supervision in the present project (%):

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions:

International partner (if Cotutelle thesis)

Surname, first name:

Position:

Employer:

Rate of thesis supervision in the present project (%):

Total rate of thesis supervision in ongoing theses (supervisions and co-supervisions) (%):

Number of current thesis supervisions/co-supervisions:

Professional status of previous PhD students supervised by both director and co-supervisors (from 5 years)

Please provide the following information for each PhD students supervised

Surname, first name: Gu, Sen

Date of PhD beginning and PhD defense: 2014-2017

Thesis supervision: Gruau / Jeanneau

Professional status and location: Associate Professeur, IHB, Wuhan, Chine

Contract profile (post-doc, fixed-term, permanent):

List of publications from the thesis work:

Gu Sen, Gruau Gérard, Dupas Rémi, Jeanneau Laurent (2020) Evidence of colloids as important phosphorus carriers in natural soil and stream waters in an agricultural catchment, *Journal of Environmental Quality* 49, 921-932.

Gu Sen, Gruau Gérard, Dupas Rémi, Petitjean Patrice, Li Q., Pinay Gilles (2019). Respective roles of Fe-oxyhydroxide dissolution, pH changes and sediment inputs in dissolved phosphorus release from wetland soils under anoxic conditions. *Geoderma*, 338:365-374. DOI: <https://doi.org/10.1016/j.geoderma.2018.12.034>. Réf. HAL: [insu-01968884](https://hal.archives-ouvertes.fr/insu-01968884)

Gu Sen, Gruau Gérard, Malique F., Dupas Rémi, Petitjean Patrice, Gascuel-Odoux Chantal (2018). Drying/rewetting cycles stimulate release of colloidal-bound phosphorus in riparian soils. *Geoderma*, 321:32-41. DOI: <https://doi.org/10.1016/j.geoderma.2018.01.015>. Réf. HAL: [insu-01713336](https://hal.archives-ouvertes.fr/insu-01713336)

Gu Sen, Gruau Gérard, Dupas Rémi, Rumpel Cornelia, Creme Alexandra, Fovet Ophélie, Gascuel-Odoux Chantal, Jeanneau Laurent, Humbert Guillaume, Petitjean Patrice (2017). Release of dissolved phosphorus from riparian wetlands: Evidence for complex interactions among hydroclimate variability, topography and soil properties. *Science of the Total Environment*, 598:421-431. DOI: <https://doi.org/10.1016/j.scitotenv.2017.04.028>. Réf. HAL: [insu-01515474](https://hal.archives-ouvertes.fr/insu-01515474).

Surname, first name: Denis, Marie

Date of PhD beginning and PhD defense: 2014-2017

Thesis supervision: Gruau / Jeanneau

Professional status and location: Cessation of research activity

Contract profile (post-doc, fixed-term, permanent):

List of publications from the thesis work:

Denis Marie, Jeanneau Laurent, Petitjean Patrice, Murzeau Anaëlle, Liotaud Marine, Yonnet Louison, Gruau Gérard (2017). New molecular evidence for surface and sub-surface soil erosion controls on the composition of stream DOM during storm events. *Biogeosciences*, 14(22):5039-5051. DOI: <https://doi.org/10.5194/bg-14-5039-2017>. Réf. HAL: [insu-01646989](https://hal.archives-ouvertes.fr/insu-01646989),

Jeanneau Laurent, Denis Marie, Pierson-Wickmann Anne-Catherine, Gruau Gérard, Lambert Thibault, Petitjean Patrice (2015). Sources of dissolved organic matter during storm and inter-storm conditions in a lowland headwater catchment: constraints from high-frequency molecular data. *Biogeosciences*, 12(14):4333-4343. DOI: <https://doi.org/10.5194/bg-12-4333-2015>. Réf. HAL: [insu-01187904](https://hal.archives-ouvertes.fr/insu-01187904)

Denis Marie, Jeanneau Laurent, Pierson-Wickmann Anne-Catherine, Humbert Guillaume, Petitjean Patrice, Jaffrézic Anne, Gruau Gérard (2017). A comparative study on the pore-size and filter type effect on the molecular composition of soil and stream dissolved organic matter. *Organic Geochemistry*, 110:36-44. DOI: <https://doi.org/10.1016/j.orggeochem.2017.05.002>. Réf. HAL: [insu-01521676](https://hal.archives-ouvertes.fr/insu-01521676)

Surname, first name: Charuaud, Lise

Date of PhD beginning and PhD defense: 2015-2018

Thesis supervision: Jardé/Le Bot (EHESP)

Professional status and location: Cessation of research activity

Contract profile (post-doc, fixed-term, permanent):

List of publications from the thesis work:

Charuaud Lise, Jardé Emilie, Jaffrézic Anne, Liotaud Marine, Goyat Quentin, Mercier Fabien, Le Bot Barbara (2019). Veterinary pharmaceutical residues in water resources and tap water in an intensive husbandry area in France. *Science of the Total Environment*, 664:605-615. DOI: <https://doi.org/10.1016/j.scitotenv.2019.01.303>. Réf. HAL: [insu-01999303](https://hal.archives-ouvertes.fr/insu-01999303),

Charuaud Lise, Jardé Emilie, Jaffrézic Anne, Thomas Marie-Florence, Le Bot Barbara (2019). Veterinary pharmaceutical residues from natural water to tap water: Sales, occurrence and fate. *Journal of Hazardous Materials*, 361:169-186. DOI: <https://doi.org/10.1016/j.jhazmat.2018.08.075>. Réf. HAL: [insu-01863750](https://hal.archives-ouvertes.fr/insu-01863750)

Five main recent publications of the supervisors on thesis subject:

Casquin A., Gu Sen, Petitjean Patrice, Gruau Gérard, Durand Patrick (2020) [River network alteration of CNP dynamics in a mesoscale agricultural catchment](#), *Science of the total environment* 749, 141551.

Gu Sen, Gruau Gérard, Dupas Rémi, Jeanneau Laurent (2020) Evidence of colloids as important phosphorus carriers in natural soil and stream waters in an agricultural catchment, *Journal of Environmental Quality* 49, 921-932.

Laurent Jeanneau, Pauline Buysse, Marie Denis, Gérard Gruau, Patrice Petitjean, Anne Jaffrezic, Chris Flechard, Valerie Viaud. Water Table Dynamics Control Carbon Losses from the Destabilization of Soil Organic Matter in a Small, Lowland Agricultural Catchment. *Soils Systems*, 2020, 4, 2 ; doi:10.3390/soilsystems4010002 www.mdpi.com/journal/soilsystems.

Emilie Jarde, Laurent Jeanneau, Loic Harrault, Emmanuelle Quenot, Olivia Solecki, Patrice Petitjean, Solen Lozach, Julien Cheve, and Michele Gourmelon. Application of a microbial source tracking based on bacterial and chemical markers in headwater and coastal catchments. *Science of the Total Environment*, 610-611:55-63, January 2018. doi: 10.1016/j.scitotenv.2017.07.235.

Guillaume Humbert, Thomas B. Parr, Laurent Jeanneau, Rémi Dupas, Patrice Petitjean, Nouraya Akkal-Corfini, Valérie Viaud, Anne-Catherine Pierson-Wickmann, Marie Denis, Shreeram Inamdar, Gérard Gruau, Patrick Durand, Anne Jaffrézic. Agricultural practices and hydrologic conditions shape the temporal pattern of soil and stream water dissolved organic matter. *Ecosystems* 1-19, 2019 <https://doi.org/10.1007/s10021-019-00471-w>

Benjamin Abbott, Gérard Gruau, Jay P. Zanevske, Florentina Moatar, Lou Barbe, Zahra Thomas, Ophélie Fovet, Tamara Kolbe, Sen Gu, Anne-Catherine Pierson-Wickmann, Philippe Davy and Gilles Pinay. Unexpected spatial stability of water chemistry in headwater stream networks. *Ecology Letters*, 21(2) :296-308, 2018. Doi : 10.1111/ele.12897. URL <https://hal-insu.archives-ouvertes.fr/insu-01674523>.

Lise Charraud, Emilie Jarde, Anne Jaffrezic, Marine Liotaud, Quentin Goyat, Fabien Mercier, and Barbara Le Bot. Veterinary pharmaceutical residues in water resources and tap water in an intensive husbandry area in France. *Science of the Total Environment*, 664:605-615, May 2019. doi: 10.1016/j.scitotenv.2019.01.303.

THESIS FUNDING

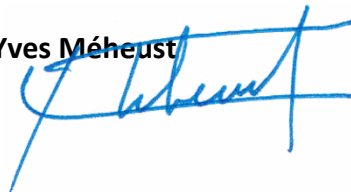
Origin(s) of the thesis funding: CDE UR1
Gross monthly salary: 1770€ gross
Thesis funding state : Non acquired
Funding beginning date/Funding ending date: 1st October 2021

Date: 25/02/2021

Name, signature of unit director: Olivier Dauteuil


Olivier DAUTEUIL
Directeur de Géosciences
Rennes UMR6118

Name, signature of team director: Yves Méheust



Name, signature of thesis project director: Gérard Gruau

