PhD Position at INRAE 2025-2028

UMR ECOlogie fonctionnelle et écotoxicologie des agroécoSYStèmes, Paris Saclay
UR Hydrosystèmes Continentaux Anthropisés – Ressources, Risques, Restauration, Antony

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Resilience to pesticides of a soil cultivated with miscanthus: consequences for the quality of groundwater recharge

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Supervisors: Julien Tournebize (HYCAR), Valérie Pot et Pierre Benoit (ECOSYS)

Contract duration: 36 mois (fully funded)

Start date: from October 1, 2025

Deadline for application : July 6, 2025

Application :

Please send a cover letter and CV to:

Valérie Pot : valerie.pot@inrae.fr
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Context and research objectives

Drinkable water production areas (WPAs) intended for human consumption are faced with pollution from agricultural sources. In response to the deterioration in drinking water quality, nearly 8,000 of France's 33,000 catchment areas were abandoned between 1994 and 2013. These abandonments are largely (40%) due to diffuse pollution by nitrates and/or pesticides (https://aires-captages.fr/livre-enrichi). Solutions for preserving WPAs require the implementation of better watershed management

practices. The planting of miscanthus crops is mentioned as a solution. This herbaceous perennial plant recycles nutrients and requires no fertilizer or phytosanitary treatment after its first year of cultivation (Strullu et al., 2011 ; Leroy et al., 2022). It can therefore act as a buffer, collecting nitrates from the soil and reducing their transfer to groundwater (Ferchaud & Mary, 2016). With the exception of the year of planting, when herbicide use may be necessary to successfully establish rhizomes, the high plant cover no longer allows weeds to develop (McCalmont et al., 2017). The use of this plant in WPAs could improve the quality of recharge water and thus speed up the restoration of drinking water quality.

The presence of numerous pesticide residues in the soil long after they have been applied and their theoretical degradation, raises questions about their actual persistence in ecosystems (Chaia-Hernandez et al., 2017 ; Silva et al., 2019 ; Froger et al., 2023). The risk of pesticides leaching into the water table is multi-factorial, since it depends on the physico-chemical properties of the molecules, the type of soil, climatic conditions and farming practices (Cueff et al., 2020). Moreover, this risk concerns not only the parent molecules applied but also the transformation products (TP), which are sometimes more mobile, more persistent and can be more toxic (Gassmann, 2021 ; Anagnostopoulo et al., 2022 ; Dong, 2024). Models of pesticide fate in the soil-plant-atmosphere system are tools used for pesticide registration in Europe (FOCUS 2000). These models do not cover the complexity of the transformation reactions that produce metabolites or transformation products, and the scarcity of data from in situ monitoring measuring concentrations and flows of these TP in soils and water leaving agricultural plots makes it difficult to calibrate these models (Gassmann, 2021).

The overall aim of the PhD position is to assess the impact of miscanthus crop on the resilience of a drained agricultural soil to pesticide pollution, in order to determine the suitability of establishing this crop in agricultural soils in WPAs.

PhD's Tasks :

You will be in charge of:

- the temporal field monitoring of water quantity and quality (nitrate, dissolved organic carbon, major elements, pesticide residues and TP) at the drain outlets of the two established neighbouring plots, one planted with miscanthus and one planted with crop rotation (rapeseed, wheat, barley).
- Improving the water and reactive solute 1D model of INRAE (Lafolie et al., 2014 ; Aslam et al., 2018 ; Benoit et al., 2023) by implementing multiple TP of some selected parent molecules measured in the field. To select the TP and parameterization of their environmental behaviour you will make use of

published database (EnviPath, Wicker et al., 2015) and QSAR-based approaches (Fenner & Tratnyek, 2017) or classification approaches (Typol, Servien et al., 2014).

- including a drainage condition in a 1D model. You will use the concepts developed in PESTDRAIN model (Branger et al., 2009 ; Henine et al., 2022) and calibrate with long-term database (Tournebize et al., 2021)
- parameterizing and calibrating the model for miscanthus crop with the help of the STICS crop model which has been calibrated for miscanthus (Ferchaud & Mary, 2016)
- modelling the water and pesticides (residues and TP) measured in the miscanthus plot with the new model over ideally three years
- building and carrying out longer-term prediction scenarios (5-10 years) and assessing the role of miscanthus in restoring the quality of drinking water.
- providing uncertainties of the occurrence and level of contamination of TP and pesticide residues in the soil and water recharge
- publishing your results in international scientific journals and presenting your findinds in national (French) and international scientific conferences

Modelling work will be carried out in parallel with the field study, outside the hydrological season sampling periods.

Provisional timetable for the work program:

Program	0-6 months	6-12 months	12-18 months	18-24 month	24-30 monts	30-36 months
Litterature review	x x x					*
Task 1						
Filed monitoring (water quantity and quality at the drain outlets)	x x x x x x	x x x	x x x x x x	x x x	x x x x x x	x x x
Field monitoring (soil profiles, quality)	x	x	x	x	x	x
Pesticides and TP analyses in the lab	x	x		x	x	x
Task 2						
Developing a multi-TP module on the Vsoil platform (TP selection and parameterization, coding)	x x x	x x x x x				
Coupling drainage module of PESTDRAIN and the 1D model		x x x	x x			
Task 3						
Modeling water and pesticide transfer of the miscanthus plot (calibration)			x x x x x x	x x x x x x	x x	
Scenarios					x x x x	x x x
Publications						
Paper 1 (Field monitoring)		x x				x x x
Paper 2 (Modeling of the miscanthus plot)				x x	x x	
Paper 3 (Scenarios)						x x x x
PhD manuscript writing						x x x
Conferences						
Groupe Français des Pesticides		x		x		
EGU				x		

Place of work and funding:

The job will take place at UMR ECOSYS (Université Paris-Saclay, INRAE, AgroParistech, Palaiseau, France) in close collaboration with UR HYCAR (INRAE, Antony, France). The PhD is funded by the ANR MisEauVert project (2024-2028) entitled "Ecosystem services of miscanthus to restore water quality and soil fertility". You will participate in project meetings and present your results.

Contacts :

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UR HYCAR : Julien Tournebize (julien.tournebize@inrae.fr)

Resources available for you:

IT resources

Access to Vsoil platform codes, PESTDRAIN code

Existaing data sets (Seine et Marne)

Laboratory for analysis of pesticide concentrations and TP for targeted parent molecules (organic chemistry platform of UMR ECOSYS) and subcontracted laboratories for screening analyses.

Skills required:

Master 2 and/or engineering degree in agronomy, soil sciences. Knowledge of hydrology and programming desirable. Skills in environmental chemistry would also be

appreciated. Aptitude for field measurements and modeling. Desired skills: curiosity, rigor, teamwork. Driving license would be a plus.

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