Title of the thesis: COMBINED - Efficiency of co-composting of biochar and digestate to reduce nitrogen emissions from organic waste recovery processes and produce fertilizers.

Rennes (35)

Context and challenges

One of the major challenges in developing optimized energy and agronomic valorisation of organic waste and residues is to promote innovative technological cascades, which minimize environmental impacts and allow the development of a bioeconomy in the territories. If we consider the production of renewable energy on the basis of biomass, two main pathways emerge: anaerobic digestion (AD) and thermo-conversion (pyrolysis / gasification). At the same time, composting is still a widespread solution for the transformation / stabilization of organic waste before returning them to soil. These three types of processes result in various products: energy, high value-added oils, digestate, biochar and compost. However, there are limits and questions for each of them. Thus, AD leads to the production of digestate characterized by its high nitrogen content, especially ammoniacal nitrogen whose behavior can significantly differ from that of a non-digested organic product. An increased ammonia emission potential has thus been observed during the storage and the return to the soil of digestate. These emissions will also appear during the composting of the solid digestate, which remains currently the main way to obtain a product status for digestates. Pyrolysis produces biochars that raise questions about their agronomic effects. Finally, one of the limits of the composting process lies in the nitrogen losses (NH_3 and N_2O) which cause a negative environmental impact and furthermore lower the agronomic interest of the product obtained. In particular, the comparison of composting of non-digested waste and digestate shows higher emissions in the case of digestates, for which losses of nitrogen can reach 70% of the initially contained nitrogen. In addition, N_2O emissions are frequently observed in a late phase of digestate composting. The challenge of minimizing nitrogen emissions during digestate composting is therefore crucial to limit the environmental impact of the treatment but also to optimize the fertilizing value of the digestate composts.

One perspective to answer these questions could lie in the proposal of a technological cascade jointly valorizing digestate and biochar by composting into a fertilizer with high added value. Indeed, different approaches are explored to reduce nitrogen emissions in composting: modification of the C/N ratio; modification of aeration conditions; change in pH conditions; inoculation of microorganisms of interest; physical barrier. The most developed approach nevertheless remains the addition of a bulking co-substrate, to trap ammoniacal nitrogen. However, the interest of such a trapping can be proved only if the bulking agent is preserved in the compost at the end of treatment. Among the structuring materials that can be kept in compost, there is an increasing interest in the literature for biochars from waste pyrolysis processes. The addition of biochar thus seems to enhance biodegradation, in particular by modifying and activating microbial communities, and the biosynthesis of humic molecules. Regarding gaseous emissions, the effect of the addition of biochar on NH_3 emissions varies depending on the nature of the biochar, but its use in the context of

digestate composting seems to limit CH_4 and N_2O emissions. The study of the application to composting of digestates is, however, very limited and research to understand the mechanisms and effects related to the introduction of biochar during digestate composting is therefore necessary.

Description of the thesis work

The COMBINeD thesis project will have to answer the following questions: 1 / Is the synergy digestate - biochar - composting proven to reduce nitrogen emissions and obtain a fertilizer of interest? ; 2 / What is the feasibility of implementing this synergy? To answer these questions, the thesis project will develop two approaches:

- a process engineering approach that will study the processes involved and, for specific case studies, optimize the conditions for implementing the technological synergy;
- a more systemic approach, which will aim to establish the modalities favorable to the implementation of the technological cascade and will begin its technical and environmental analysis

These approaches will be developed via 5 tasks presented below.

Task 1 (T1): Bibliographical review of knowledge on digestate - biochar - composting synergies

The main objective of this task will be to identify which factors (intrinsic to the substrate and / or from the operational management of composting) can control the limitation of nitrogen losses in composting and the quality of the final compost. The results obtained will lead to a choice of factors to be tested experimentally for the rest of the work.

Task 2 (T2): Experimental Screening of the Influence of Operational Factors in Composting Digests with Biochars

Based on the results of task 1, an experimental design will be established to determine the most important determinants of digestate and biochar composting performance: e.g. type of digestate, type of biochar, mode contribution, ratio, etc.

Task 3 (T3): Thorough understanding of the processes involved

The results of Task 2 will be used to select one or two operational modalities on which the processes involved in composting will be studied.

Transversal task 1 (TT1): Evaluation of the organizational, technological and environmental potentialities of the technological cascade: anaerobic digestion - pyrolysis - composting

This task will not aim at developing an academic methodological work on the assessment of a waste management system. It involves acquiring system analysis elements both to feed the process engineering work and to provide operational perspectives for the results.

Transversal task 2 (TT2): Training of the doctoral student and exploitation of the results

This second transversal task aims to take into account, from the start of the thesis, the time required for the PhD student to achieve the quotas for mandatory training during the PhD (100 hours) and finalize the forecasted scientific papers (3).

Home structure

The doctoral student will be attached to OPAALE research unit "Optimization of processes in agriculture, agro-food industry and environment" of the Irstea centre of Rennes. Among its research topics, the unit studies organic waste transformation processes in the context of the establishment of recycling value chains as well as the environmental and health impacts and the organizational and technical aspects attached to these value chains. To do this, researchers develop in particular experimental approaches for which they have an experimental hall equipped with pilot reactors and analysis laboratories in chemistry, microbiology and molecular biology.
(https://www.irstea.fr/fr/recherche/unites-de-recherche/opaale)

Framework of the thesis

Framing

Direction of thesis: A. Trémier (Research Director - digestates and composting)

Complementary supervision: P. Dabert (microbiology); R. Girault (gaseous emissions)

Doctoral School

ED EGAAL "Ecology, Geosciences, Agronomy, Food", Brittany-Loire University

Duration

36 months from the fall of 2019

Funding

Irstea doctoral contract

Candidate Profile

Master 2 or engineer degree in the field of process engineering. Knowledge in biological engineering (aerobic and anaerobic process) and basic knowledge of analytical techniques in microbiology will be appreciated as well as basic knowledge in interface chemistry. Pre-awareness of environmental analysis would be a plus.

The candidate will also have a strong taste for experimental work. His/her writing and oral skills in French and English will be assessed during the selection process

How to apply

Submit CV and cover letter on the website https://pasi.irstea.fr (Project n°4175)

Contact

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