AGENCE NATIONALE DE LA RECHERCHE

Public abstract

Project Identification

Acronyme	DIVA
Titre	**Caractérisation des DIgestats et de leurs filières de Valorisation Agronomique**
Programme – Edition	Programme BIOENERGIES 2010
Reference ANR	ANR- 10-BIOE-007
Contact coordinator (Nom, Institute, mail)	Patrick Dabert, Irstea (ex Cemagref), patrick.dabert@irstea.fr
Partners (society, organisms, labs)	IRSTEA, Solagro, ARMINES, Université de Montpellier II – LGPEB, INRA, GEOTEXIA, Suez Environnement
Starting Date Ending Date	1 décembre 2010 30 novembre 2014
Poles of competitivity	AgriMip Innovation Laurent Augier, Directeur Projets Laurent.Augier@agrimipinnovation.com
Full Cost	3 817 104 euros
ANR Funding	1 226 387 euros
Web Site	http://diva.irstea.fr/
Document	July 17th 2015

How to value digestate from anaerobic digestion?

Technical, agronomic, economic and environmental assessment of the benefits of managing digestate by (i) direct spreading or (ii) phase separation followed by drying or composting of the solid phase and biological treatment or membrane filtration of the liquid phase.

1. The challenges of managing digestate

Political incentives of the past 10 years have led to a diversification of biogas production to agricultural waste (farm's waste alone or mixed with other waste from a territory), biowaste and residual household waste. However, despite their recognized value (renewable energy production, capture of greenhouse gases emissions (GHG), recycling of organic matter), these sectors are struggling to grow, partly due to a lack of effective valuation of digestate.

Digestates are organic residues generated during the anaerobic digestion process. It represents a volume equivalent to the one of the treated waste and has characteristics depending on its origin. Nowadays, digestates have a status of waste and can only be managed by a spreading plan or composting.

The objective of DIVA was to acquire knowledge on the composition of digestates and on their post-treatment systems in order to assess the risk /benefit of their use in agriculture and to provide data to stakeholders. Several technological solutions were evaluated and compared to the option of a direct application of raw digestate: phase separation and application of separate phases or after treatment by drying or composting for solid phases and biological treatment or membrane filtration for the liquid phases.

2. The sectors studied and the methods implemented in DIVA

The project focused on 2 farm anaerobic digesters, 1 territory digester and 2 digester-composting plants of urban waste (1 treating biowaste and 1 treating the fermentable fraction of household waste). Five sampling campaigns were carried out on 1 year for each site with collection of raw digestate, separated digestates (solid and liquid phases), and where possible post-processed digestates (composts, dried digestate, membrane filtration condensate). In the absence of a regulatory framework for digestate, their physical and chemical characteristics were analyzed using existing standards for fertilizer and amendment (NFU44-051, NFU44-095 and NFU42-001) and by rheological tests, dehydratability, and biological activity (respirometry, methanogen potential).

The behavior of raw and separated digestate (liquid and solid phases) of the five sectors was studied in laboratory pilots during various post-processing: drying or composting for raw digestates and solid phases, biological oxidation or membrane separation for liquid phases. Whenever possible, the performance in terms of sanitization, drying, gaseous emissions and energy consumption during processing was determined. The composition of the products obtained was analyzed.

The agronomic value of raw, separated and post-processed digestates, and the benefits/ risks associated with their return to the soil, were determined by tests in the laboratory and in the field, and modeling. These tests were used to determine the nitrogen fertilizer value and risk of volatilization of ammonia and N_2O emission in the short term after spreading. The contribution to soil in the medium term, carbon (C) and nitrogen (N) mineralization dynamics and the ability of the contributions of digestates to maintain organic matter stocks in soils, risk of phytotoxicity and simulation of C and N fate into the field were determined.

The data obtained by the project partners combined with data from real sites and, when necessary, bibliographic data were used for the environmental assessment (using the Life Cycle Analysis) and the economic evaluation of digestate post-treatment in comparison to a direct application of raw digestate.

3. Project main results

The composition and physical properties of raw digestate depend on the composition of the digested waste but does not change dramatically (less than 10 %) for the same sector despite the big variation of waste entering the digester. This observation is important for digestate homologation that requires constant composition and behavior of approved products.

The flow properties and the mechanical dewatering capacity of digestate can be defined from their amount of dry matter and the ratio: organic matter / dry matter. These data can be used for the design of spreaders and presses.

The **phase separation post-treatment**, by separating ammonia and potassium in the liquid phase on one side and carbon, phosphorus and metals in the solid phase on another side, removes the link between the composition of the waste digested and the one of the digestate. This is an interesting step in anaerobic digestion plants because it enables an overall reduction of the N_2O emissions (greenhouse gas) by spreading the separated phases compared to spreading raw digestate.

Drying the solid phase of digestates causes the volatilization of 75% of the ammonia at 70°C and 100% above 90°C. It therefore leads to a significant loss of the digestate fertilizer value. All digestate drier must thus be equipped with an effective system for collecting the vapors to prevent emissions into the atmosphere and ensure the safety of workers on site. Hot air drying technology used for on-farm anaerobic digestion, does not allow for sanitization of digestate as it does not destroy spores of *Clostridium perfringens*. Drying by contact - agitation, with longer residence times and higher temperatures in the product, sanitizes digestate but generates a powdered product that posed technical problems during handling. This problem did not arise for hot air drying processes.

Composting of raw or solid phase digestates may require the addition of structuring and /or co-substrates to obtain a correct temperature rise. However, it can be used to dry the digestate. The high ammonia content digestate causes significant emissions at the beginning of composting. There is therefore still an important loss of the digestate fertilizer value. As for drying, these emissions must be captured to prevent air pollution and ensure the safety of workers on site.

Nitrification of liquid digestate prevents ammonia emissions while keeping the nitrogen in the digestate, this line of research could be better explored.

Membrane filtration processes require significant pretreatment of liquid digestate to limit membrane clogging problems. However, they allow capturing over 93% of the residual organic matter and 95% of digestate ions to produce a colorless liquid.

Digestate have **agronomic properties** close to both fertilizers and amendments, largely explained by their ammonia nitrogen content and stabilized organic matter. The land application must be mastered to limit volatilization which may cause the loss of 30-84% of ammonia nitrogen. Once in the soil, digestate induce N_2O emissions superior to that of mineral fertilizers. These emissions are greater for digestate which have a low C / Norg. Field trials did not show very positive or negative effect of digestate on crops yields, with fertilizers equivalent coefficients measured from 40 to 50%.

The **assessment** analysis shows that direct application of digestate is the most efficient solution and, in general, with the less impact at global environmental level. The most advanced post-treatments have a real interest either in a context of nitrogen or phosphorus surpluses which impose digestate exportation, or in a marketing process to generate new products.

4. Prospects

Because of its scope, the DIVA project has tested different possibilities to get an overview of sectors and technologies of digestate management. The remaining locks are multiple:

Regulation. Digestates do not satisfy any of the existing standards, it is necessary to continue to apply for homologations to get advance in the legislation and better knowledge of digestate. In this sense, a work and deep questioning should be undertaken about the use of enterococci and *Clostridium perfringens* as indicators for which current standardized methods are problematic.

Technology. The work done and many returns of information collected on site showed that the implementation of digestate post-processing requires optimization to achieve desired product quality. Most of the processes installed on site are only poorly or not working at all. Their maintenance costs have been greatly underestimated. Moreover, it is absolutely necessary to work on the recovery of ammonia emissions from dryers and from composting for, at least, reduce emissions to the atmosphere and ensure the safety of workers and, better, capture and recycle nitrogen.

Agronomy. Beyond the necessary needs in data and modeling, it appears that field trials are still needed to test the efficiency of digestate spreading (available technologies), confirm and predict digestates value as fertilizer equivalent coefficient and validate the long-term safety of their application.

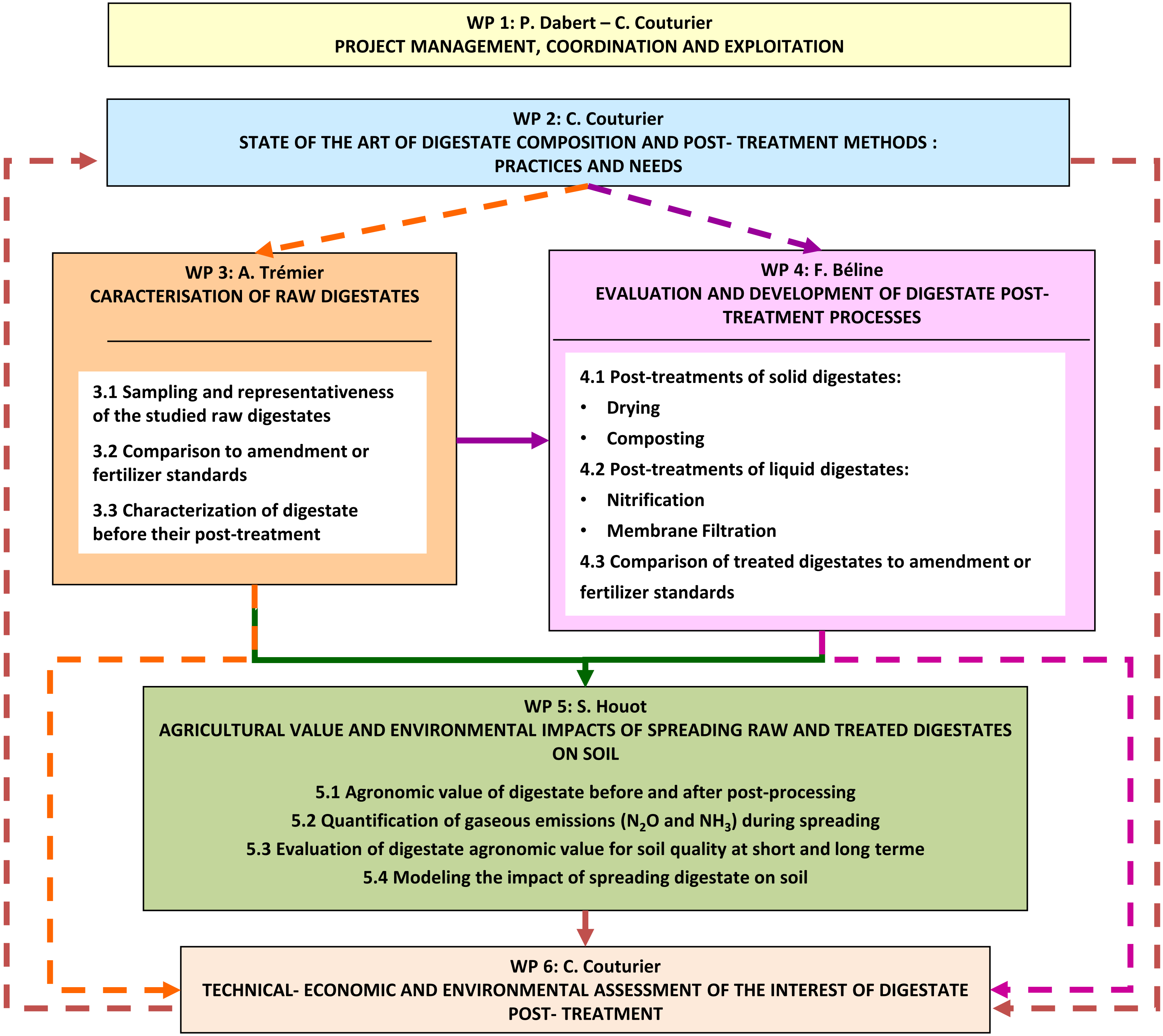
Environmental analysis. The Life Cycle Assessment method is used to assess the environmental impacts of a service, which is quantified by the means of functional units applied in a defined area. The global character of this method has raised questions on the interest of post-processing digestate, without obtaining firm answer. LCA still requires many developments for the assessment of localized impacts, which is absolutely necessary in the case of application of waste on soil.

5. Scientific production and patents since the project began

Work in DIVA was presented in 24 international conferences, 16 public conferences and published in 4 scientific publications. However, the impact of DIVA was more visible at national level by presenting the results every year to a monitoring committee made up of stakeholders in the sector, associations, collectivities and ministries; participating in the steering committees of the CASDAR Valdipro project for the approval of agricultural digestate and by presenting of work at the BN Ferti and national conferences.

6. Illustration

Unit of centralized anaerobic digestion. Picture from P. Dabert.


WP 1: P. Dabert – C. Couturier
PROJECT MANAGEMENT, COORDINATION AND EXPLOITATION
WP 2: C. Couturier
STATE OF THE ART OF DIGESTATE COMPOSITION AND POST- TREATMENT METHODS :
PRACTICES AND NEEDS
WP 3: A. Trémier
CARACTERISATION OF RAW DIGESTATES
3.1 Sampling and representativeness of the studied raw digestates
3.2 Comparison to amendment or fertilizer standards
3.3 Characterization of digestate before their post-treatment
WP 4: F. Béline
EVALUATION AND DEVELOPMENT OF DIGESTATE POST-TREATMENT PROCESSES
4.1 Post-treatments of solid digestates:
• Drying
• Composting
4.2 Post-treatments of liquid digestates:
• Nitrification
• Membrane Filtration
4.3 Comparison of treated digestates to amendment or fertilizer standards
WP 5: S. Houot
AGRICULTURAL VALUE AND ENVIRONMENTAL IMPACTS OF SPREADING RAW AND TREATED DIGESTATES ON SOIL
5.1 Agronomic value of digestate before and after post-processing
5.2 Quantification of gaseous emissions (N_2O and NH_3) during spreading
5.3 Evaluation of digestate agronomic value for soil quality at short and long terme
5.4 Modeling the impact of spreading digestate on soil
WP 6: C. Couturier
TECHNICAL- ECONOMIC AND ENVIRONMENTAL ASSESSMENT OF THE INTEREST OF DIGESTATE POST- TREATMENT