Bovine livestock waste recovery and reuse

Summary

In recent years the livestock population has significantly increased in Catalonia, while the useful agricultural surface area has decreased. Therefore, in high-density livestock areas it is necessary to develop and implement technologies that enable excess livestock excrement that cannot be safely used as fertiliser to be reused. An option for the use of this excrement is the application of the biodrying process for energy recovery. Biodrying as applied in the livestock industry is an innovative process that yields a biofuel (LHV > 2,500–3,500 kcal/kg) that can be used in conventional biomass boilers. Biodrying is similar to composting, but its final objective is different. While the aim of composting is to maximise the stability of organic waste through the mineralisation of organic carbon, that of biodrying is to use the metabolic heat produced by the biological activity to remove water from the waste matrix in the shortest time possible, minimising the degradation of carbon and preserving the majority of the heat value of the matrix.

Objectives

The main objective of the project is the development and optimisation of the cattle manure biodrying process with the aim of obtaining a biofuel suitable for use in conventional biomass boilers.

Description of the actions carried out in the project

1) Design for the subsequent adaptation of part of the composting plant as a biodrying pilot plant. Modification of the aeration system, development of a control system based on the control of biological activity and initial definition of operating conditions.

2) Construction of the biodrying pilot plant based on modifying one of the existing trenches in the composting plant. This phase included changing some of the equipment in the current infrastructure (such as fans and pumps) for the construction of the new pilot plant.

3) Implementation and optimisation of the biodrying and co-biodrying process. Co-biodrying tests include mixing manure with sewage sludge from the treatment plant. These co-biodrying processes help improve process efficiency to obtain a biofuel with a higher calorific value while minimising production of other waste that currently requires external management.

4) Solar drying pilot tests. This was not initially scheduled within the project, but the decision was made to carry out solar drying in a greenhouse to see whether the dryness of the mixture could be improved, after which the procedure was repeated with the fresh solid fraction taken directly from the solid-liquid separator outlet.

5) Combustion of the new biofuel. Combustion of the biodried material was carried out and gas emissions analysed to ensure they were below the legal threshold.

6) Technical, environmental and economic assessment of the process using life cycle analysis (LCA) and cost cycle analysis techniques.

Final results and practical recommendations

The results obtained show that weather conditions affect the biodrying process. For this reason, it was decided to cover the pile on rainy days and turn the mixture over daily. Figure 1 shows the moisture results for the mixture over the biodrying cycle and the rainfall values. As can be seen, by covering the pile, the rain does not cause an increase in the moisture of the mixture, although occasional measurements show increases due to high atmospheric humidity. A material with 50% moisture was obtained after 50 days of operation, contrary to expectations.

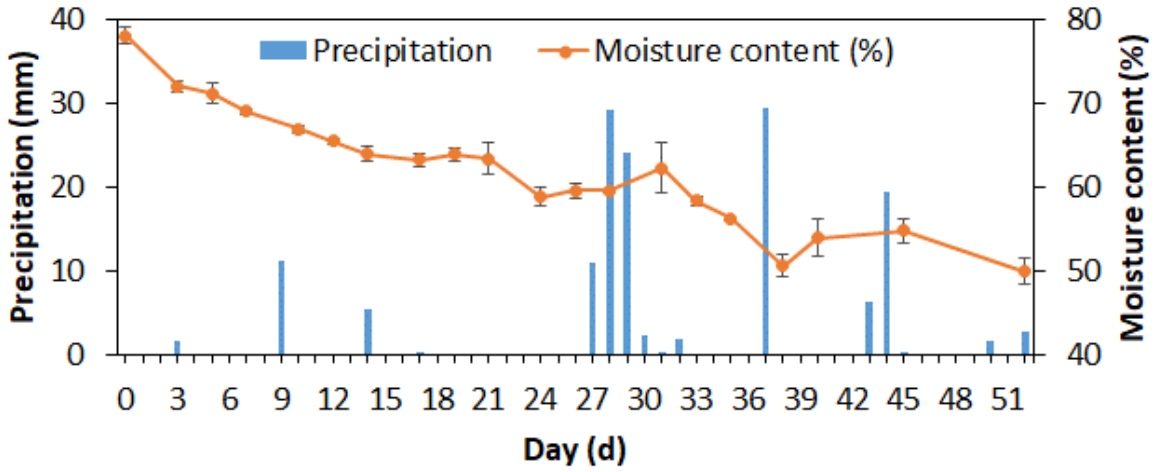

Figure 1. Results obtained in the biodrying cycle with the pile covered on rainy days and turning the mixture over daily.

Calorimetry measurements of the material were taken from different samples during the process to determine the lower heating value (LHV, Figure 2). As can be seen, the fresh solid fraction has an LHV of around 1, reaching values of 5.60 MJ/kg at the end of the bio-drying process. The drying was forced so as to observe the levels of dryness required for viable combustion, establishing a level of 40%. The LHV was then observed to be greater than 7 MJ/kg.

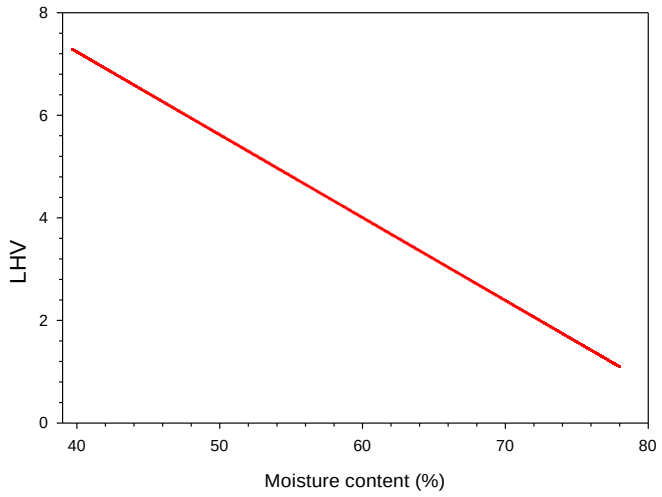

Figure 2. Lower calorific value of the samples during the biodrying process.

This was not scheduled within the project, but because a level of dryness good or fast enough for combustion tests could not be obtained, it was also decided to perform solar drying in a

greenhouse. In the fresh solid fraction solar drying test (Figure 3), it was observed that, despite overcast conditions, 7% moisture was reached in 17 days.

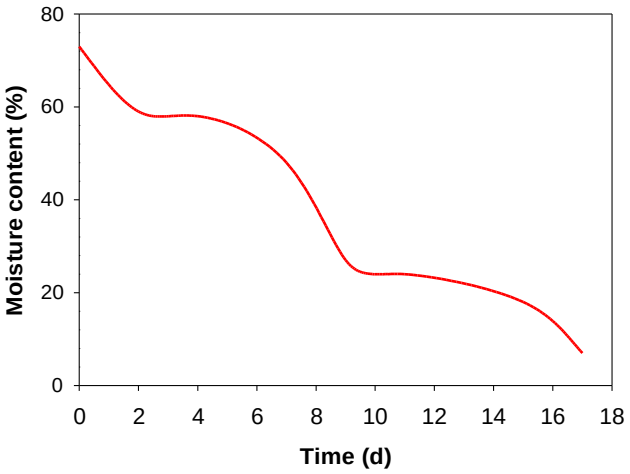

Figure 3. Moisture profile of the fresh solid fraction during solar drying.

LHV tests were also performed on solar drying samples (Figure 4). At the end of the process, the LHV was found to have reached 12 MJ/kg. A sample was dried in the stove to see what values could be reached, observing a maximum value of almost 14 MJ/kg. These results mean the main target described in the project report, "**obtaining a biofuel with a humidity <30% and a LHV>2500 kcal/kg**" was reached.

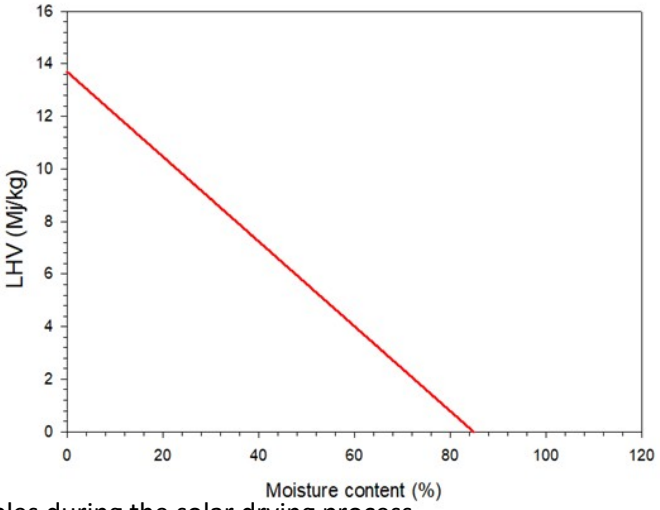

Figure 4. LHV of the samples during the solar drying process.

The results of the LCA when analysing implementation of biodrying and incineration in the livestock waste management system of La Fageda are presented in Figure 5. As can be seen, the biodrying phase mainly affects the environmental impact categories assessed, while incineration of the dry solid fraction produced by obtaining energy generates environmental credit in all the impact categories analysed.

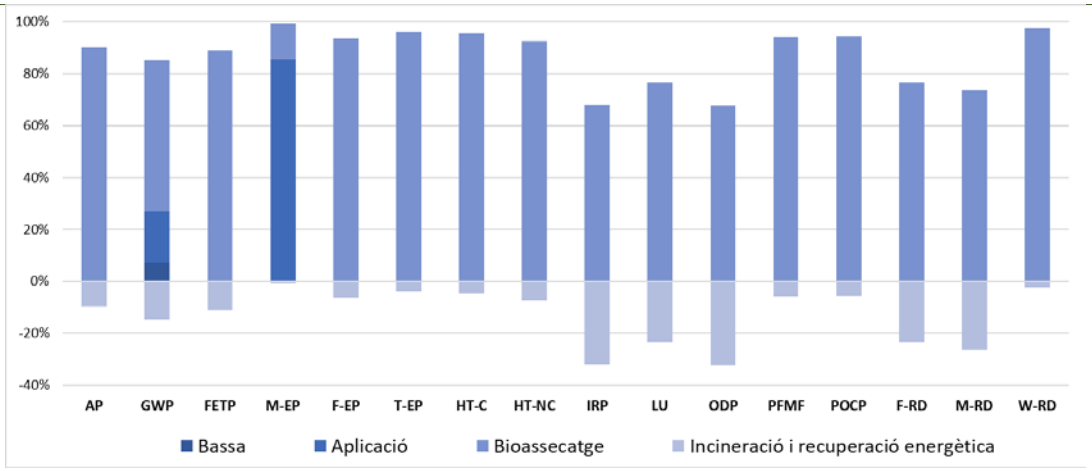

Figure 5. Contribution of the different processes in the La Fageda livestock management system to the different environmental impact categories assessed.

A possible improvement for optimising the livestock waste management system in La Fageda involving a biodrying stage would be to install a solar power plant to generate electricity for the aeration pumps. Clearly, use of renewable sources to produce energy will have a significant positive impact, but the economic feasibility of implementing these improvements in the process must also be analysed.

As can be deduced from the NPV results, the IRR of the biodrying process is negative as the investment does not generate positive returns at any discount rate. Furthermore, solar drying has an IRR of 24.75%, a very high value due to the low investment required and high amount of energy recovered. If there is an existing composting plant, biodrying estimates an IRR of 8%, a reasonable value that suggests a good return on investment. The ROI period in the case of solar drying is 5 years; if there is an existing composting plant, the return on investment period for biodrying is 11 years. If the composting plant is built from scratch, it takes more than 25 years to recoup the investment.

Conclusions

- After 50 days of operation, it was observed that the pile moisture was 50%, higher than desired, as combustion requires values of less than 40%.
- The LHV value observed with the mixture at 50% was 5.6 MJ/kg, but after forcing moisture to 40%, the LHV values increased to over 7.2 MJ/kg. Therefore, if the material can be dried to 40% moisture, it would be worth carrying out the combustion.
- Tests performed on solar drying samples obtain lower moisture values much faster (reduction of 60-70% moisture between 7 and 14 days). These results mean the main target described in the project report, "**obtaining a biofuel with a humidity <30% and a LHV>2500 kcal/kg**" was reached.
- The ROI period in the case of solar drying is 5 years; if there is an existing composting plant, the return on investment period for biodrying is 11 years. If the composting plant is built from scratch, it takes more than 25 years to recoup the investment.

Leader of the Operational Group

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Subject area(s) of application

☐	Agricultural production system
☐	Agricultural practice
☒	Agricultural equipment and machinery
☐	Livestock farming and animal welfare
☐	Vegetable production and horticulture
☐	Landscape / Territorial management
☐	Pest and disease control
☐	Fertilisation and nutrient management
☐	Soil management
☐	Genetic resources
☐	Forestry
☐	Water management
☐	Climate and Climate Change
☒	Energy management
☒	Waste and by-product management
☐	Biodiversity and environmental management
☐	Food quality/processing and nutrition
☐	Supply chain, marketing and consumption
☐	Competitiveness and agricultural and forestry diversification
☐	General

Geographical area(s) of application

PROVINCE(S)	REGION(S)
Girona, Barcelona, Lleida and Tarragona	All

Dissemination of the project (publications, seminars, multimedia, etc.)

The dissemination of the project was via social media posts by the CT Beta account. Entries were made in the University of Vic (UVic) media, such as Apunt (UVic Information Blog).

The results are being studied for scientific publication in one of the international journals specialising in the treatment and application of livestock waste, as well as in soil fertilisation.

More information on the project	
PROJECT DATES	TOTAL BUDGET
Start date (month-year): June 2018	Total budget: €115,000.00
Completion date (month-year): September 2020	DARP funding: €45,885.00
Current status: Executed	EU funding: €34,615.00
	Own funding: €34,500.00

With funding from:

Project funded through Operation 16.01.01 (Cooperation for Innovation) through the Catalan Rural Development Programme 2014–2020.

Order ARP/133/2017 of 21 June, approving the regulatory bases for grants for cooperation for innovation by promoting the creation of European Association for Innovation operational groups in the areas of agricultural productivity and sustainability and the execution of innovative pilot projects by those groups, and Resolution ARP/1868/2017, of 20 June, announcing the call for the grant.

Generalitat de Catalunya
Departament d'Agricultura, Ramaderia, Pesca i Alimentació

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Europa inverteix en les zones rurals