LIFE12 ENV/ES/000689
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Valorization of the digestate from pig manure as new fertilizers with an organic / mineral base and gradual release

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Project Data

Project location:	Soria (Spain)
Starting date:	01/09/2013
Ending date:	31/08/2016
Total budget:	1.258.717 €
EU Contribution:	617.232 €
% Elegible costs:	49%

Coordinator data

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ENVIRONMENTAL PROBLEM

The European Union is the second worldwide producer of meat, behind China, with 46.8 million tonnes, which is 14% of the world production.[1] Within the livestock sector, **swine production** is the first concerning the economic importance. In Europe, pig herd was foreseen in 148.5 million animals for 2015, being **Spain and Germany** the countries were a bigger number of animals was found (figure 1).[2]

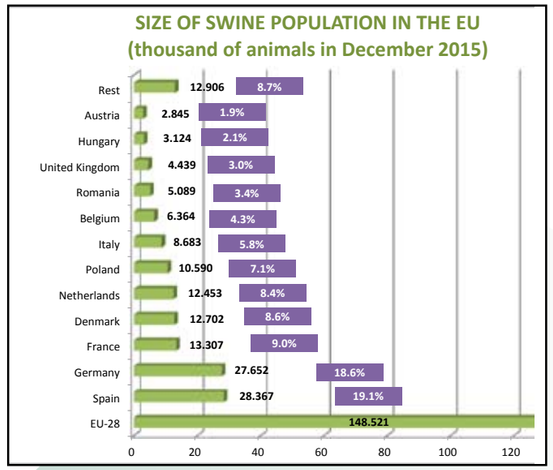

Figure 1. Size of swine population in the European Union (Source: MAPAMA, 2015)

As consequence of this activity, only in Europe, 178 million of m^3 of swine manure are generated, volume which would fill up to 71000 olympic swimming pools.

Pig manure has a **high potential as fertilizer**, thanks to its content in organic matter and nutrients such as nitrogen, phosphorus or potassium, among others. This agricultural use of pig manure is only feasible when there is a balance between agriculture and livestock. Thus, Spanish Royal Decree 91/676 sets the maximum amount that can be dosed in **170 kg of nitrogen per hectare and year**. When livestock farming is intensive, the volume of pig manure to be managed may exceed the amount that can be used for the available soil. These imbalances can lead to serious environmental problems affecting **soil** quality (accumulation of heavy metals, pathogens or phosphorus), **water** (groundwater contamination by nitrates or surface water eutrophication) and **air** (bad odours, emissions of greenhouse gases).

An alternative for the management of pig manure **surpluses** is the **energy valorisation** in biogas plants (figure 2). According to data from the EBA, European Biogas Association, by the end of 2015 there were in Europe 17240 biogas plants, of which only 39 were in Spain.[3] There are two reasons why the biogas sector has not reached in our country the foreseen speed of development. The first reason refers to the Royal Decree 1/2012, which suspends the bonus to new facilities of renewable energy origin, which has caused that many of the plants under construction were paralyzed. The second reason entails the need to develop regulations that define the biogas quality standards to allow its use by injecting it to natural gas networks. This is currently happening in Germany, Italy or Sweden. Spanish associations related to biogas stand for different measures to support the sector, such as incentives for production, cogeneration, or counting the CO_2 emissions avoided.

Due to the importance of biogas sector in livestock waste management and, taking into account this legislative uncertainty, it is essential to develop solutions that improve the **profitability** of treatment plants.

[1] FAO, "Food outlook. Biannual report on global food markets", Junio 2016 (http://www.fao.org/3/a-i5703e.pdf)

[2] MAPAMA, "Caracterización del sector porcino español, año 2015". (http://www.mapama.gob.es/es/ganaderia/temas/produccion-y-mercados-ganaderos/caracterizaciondelsectorporcinoespanolano2015_tcm7-423382.pdf)

[3] http://european-biogas.eu/2015/12/16/biogasreport2015/

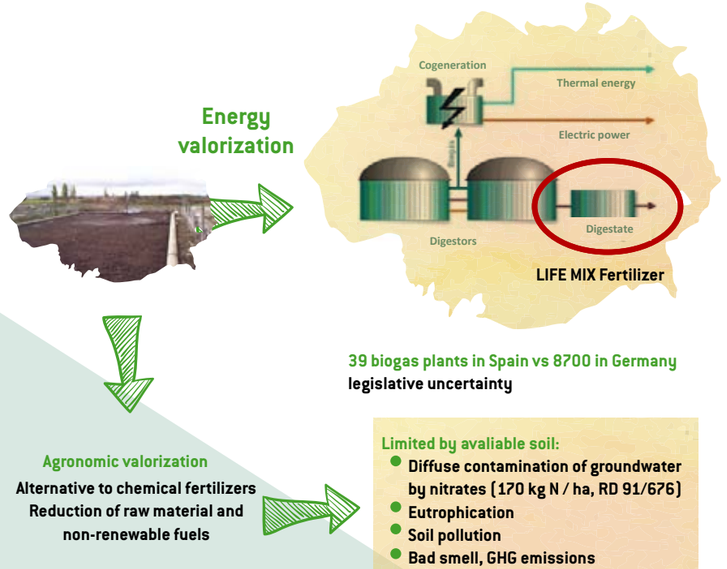

Figure 2. Management of pig manure

LIFE MIX FERTILIZER PROJECT

MIX-Fertilizer initiative has addressed the environmental issues associated with pig manure management and has been funded through the European Union's LIFE instrument.

LIFE Program is the **only financial instrument of the European Union devoted exclusively to the environment**. Its overall objective for 2004-2020 is to contribute to sustainable development and to the achievement of the objectives and targets from Europe 2020 Strategy and its relevant plans concerning environment and climate goals.

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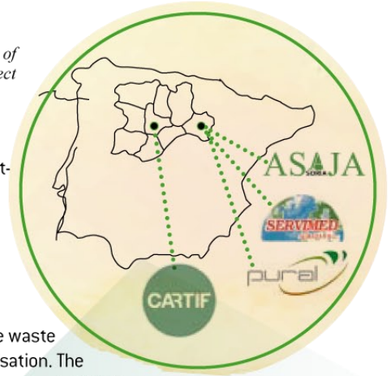

Figure 3. Beneficiaries of LIFE MIX_Fertilizer Project

The Project had budget of more than 1.2 million € and had the participation of 4 Spanish partners (figure 3):

1. **CARTIF Centro Tecnológico** – Coordinator
2. **Purines Almazán SL**. (PURAL).
3. **Servimed SL**.
4. **Centro provincial de jóvenes agricultores** (ASAJA-Soria).

The objective of the Project was to demonstrate an innovative system for the treatment of the waste from the anaerobic digestion of pig manure (digestate) and its subsequent agricultural valorisation. The Project's actions began in September 2013 and have been extended for 3 years. As result, a new type of **fertilizer with a mixed organic / mineral base of gradual release** has been obtained.

Due to their dual nature, the new fertilizers developed during the Project have a number of advantages in relation to the products currently commercialized. Those are environmental (improvement of soil quality, minimization of nitrogen losses by nitrate leaching, reduction of GHG emissions) and economics ones (costs reduction by a single application, increase of agricultural yields).

The Project will favour in the midterm, the entire **value chain** involved in the management of pig manure, stakeholders represented within the consortium itself (figure 4):

Managers of biogas plants, such as PURAL, will have an alternative to give profitability to their businesses. **Two new products** (compost and ammonium sulphate) will be obtained that can be sold as raw material for fertilizers' production.

Fertilizer manufacturers, like SERVIMED, will have a new type of product. New markets and business opportunities can be opened.

Finally, **farmers**, represented through ASAJA, will benefit from the use of this new type of fertilizer more environmentally friendly.

Figure 4. Value chain of LIFE MIX_FERTILIZER Project

LIFE MIX_FERTILIZER SYSTEM

The MIX_Fertilizer system consists of several stages of treatment (Figure 5).

The first three actions have taken place in the biogas treatment plant owned by PURAL in Almazán-Soria (figure 6). First, the crude digestate is separated in the related solid and liquid fractions. The solid fraction is composted with other organic waste such as chicken manure and vegetable biomass. In parallel, the liquid fraction is treated in a stripping plant to selectively remove the nitrogen as ammonium sulphate.

Manufacturing of the new fertilizers in the form of pellets has been carried out at a later stage of the Project. This was done by mixing the previously obtained compost and ammonium sulphate together with a nitrification inhibitor, which has been added for the nitrogen controlled release. These new fertilizers production has been carried out by SERVIMED in Almazán.

The last stage of the process has been the evaluation of the new fertilizers in ASAJA test fields in Almazán. In one hand, solid fertilizers in pellet form have been tested and validated in **late barley rainfed and irrigated crops**. On the other hand, the liquid fraction from the stripping step has been used in sunflower fertirrigation in controlled trials, also in rainfed and irrigated crops.

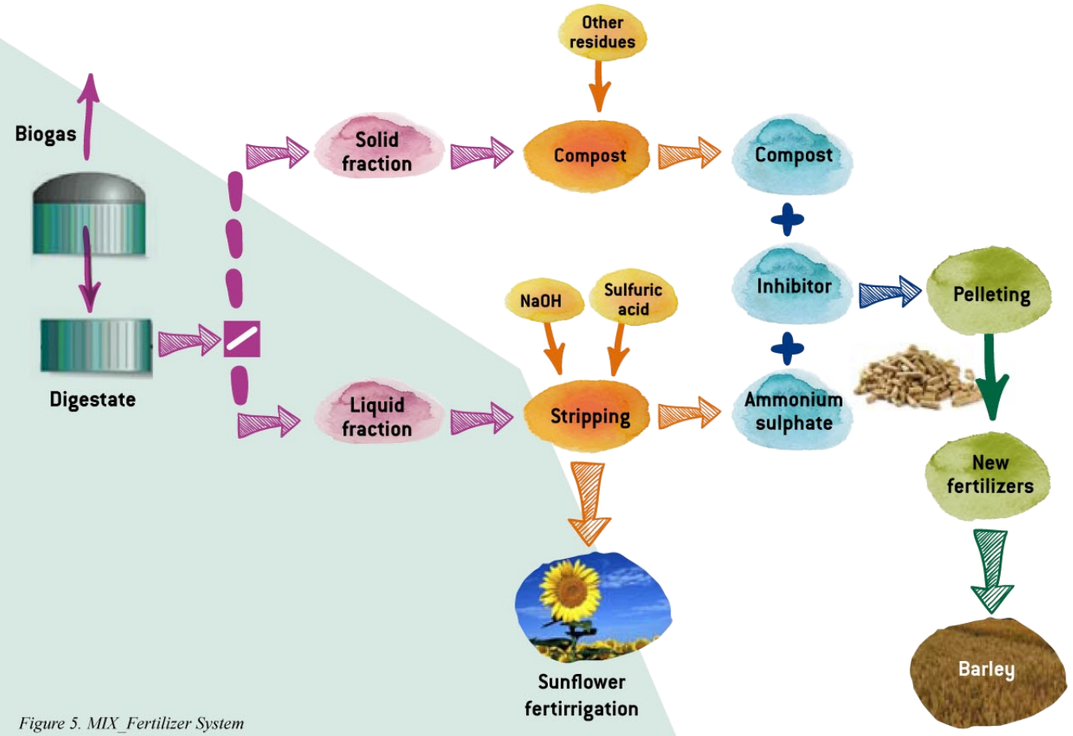

Figure 5. MIX_Fertilizer System

STAGE 1. SOLID-LIQUID SEPARATION

MIX_Fertilizer process starts with the solid-liquid separation of swine manure digestate, which has 4-5% of the total solids. This physical process is performed with a separator in order to reduce the digestate moisture content. This process will produce two fractions: the solid fraction that will be used for composting and the liquid fraction, which will undergo the stripping process (figure 7).

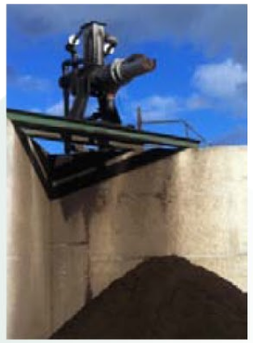

Figure 7. S/L Separator

STAGE 2. COMPOSTING OF DIGESTATE SOLID FRACTION

Composting is an aerobic biological process, where microorganisms act on the biodegradable matter providing excellent **compost** for agriculture. In the Project framework, the solid fraction of the digestate has been composted along with vegetal biomass and poultry manure. A stable and quality organic fertilizer has been obtained, ready for being directly applied to crops soil accordingly to the current legislation (RD 506/2013).

STAGE 3. STRIPPING FROM DIGESTATE LIQUID FRACTION

Stripping is a process of physical separation, which allows extracting the ammonia contained in the liquid fraction of the digestate, by means of counter current air. Under the Project, a stripping prototype plant with capacity of 40 m3/d has been used (figure 8). The opera ting conditions have been optimized to allow the recovery of 80% of the nitrogen in the form of **ammonium sulphate.**

Figure 8. Stripping Prototype Plant

Figure 6. MIX_Fertilizer stages in PURAL treatment plant

STAGE 4. NEW FERTILIZERS PRODUCTION

SERVIMED has produced new fertilizers from the composted organic waste, tl ammonium sulphate and a nitrification inhibitor for the nitrogen controlled releas In order to obtain the new fertilizers in pellet form, it has been necessary to desi a **prototype plant** consisting of a stainless steel double-axis orientable bla mixer, which has provided a perfect absorption of the inhibitor and a very hi homogenization of the organic

Three new fertilizers have been formulated in the Project with organic/mineral bas

- compost + ammonium sulphate,
- compost + ammonium sulphate + inhibitor,
- compost + ammonium sulphate + twice quantity of inhibitor.

The new fertilizers have the suitable density and diameter for being further used (figure 10). In addition, its content in metals is below the limits established for fertilizer products in the current legislation (RD 506/2013).

Figure 10. New MIX_Fertilizers

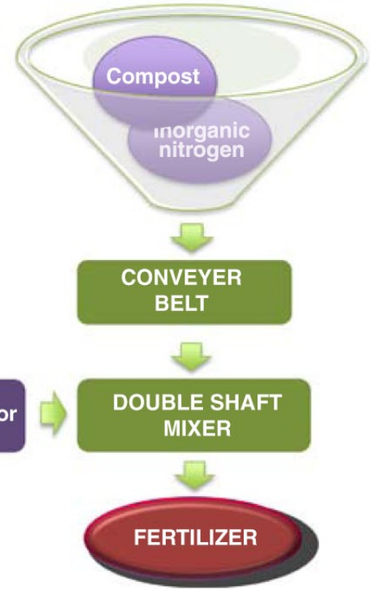

Figure 9. Diagram of prototype plant for the fertilizer production

STAGE 5. CONTROLLED TRIALS IN SHORT CYCLE BARLEY CROPS

The evaluation of the agricultural viability of the new fertilizers has been made on the basis of 3 real tests in dry and irrigated agricultural plots, with **spring barley** crops. In these tests, the three new fertilizers, raw compost and a commercial mineral fertilizer were used.

Throughout the crop cycle, the plant status has been periodically evaluated in terms of growth, phenological status, height measurement and number of plants per square meter. Likewise, the soil was analysed and characterized. Finally, quantitatively and qualitatively harvesting data on the final production were collected as well as data on soil evolution.

Concluding, the range of the new fertilizers is agricultural viable and worked well in the traditional mineral fertilization environment. As improvements, we can highlight that one of the formulas **improved yields by more than 10%** and that **soils**, after cultivation, increased their proportion of **organic matter**, which allows the recovery of the natural fertility in the long term.

Collaborating farmers:

In addition to the described trials, there were another 20 farmers who tested the new fertilizers on barley and wheat crops. All of them were satisfied about the results of the fertilizer, emphasizing their positive attitude towards requiring **a single application** compared to the two traditionally applications required in mineral fertilization.

STAGE 6. SUNFLOWER FERTIRRIGATION

The evaluation of the fertirrigation agricultural viability with the aqueous phase from the stripping plant has been carried out. For this purpose, 4 trials were carried out in dry and irrigated agricultural plots with **sunflower cultivation**.

At the tested doses with a low contribution of nitrogen fertilizers per volume unit, **no significant differences were observed** with respect to the traditional mineral fertilization for sunflower cultivation.

TECHNICAL AND ECONOMIC FEASIBILITY

The implementation of **an industrial scale plant** with the technology developed in the MIX_Fertilizer is **economically viable**. The demand for these new products has generated great interest among all the stakeholders: biogas plant managers, fertilizer manufacturers and farmers.

SOCIOECONOMIC IMPACT

At the socio-economic level, for the geographical area, LIFE MIX Fertilizer will favour the **creation of direct employment** by the development of industrial activity and indirect employment by positively affecting the sustainability of other activity sectors, especially the swine sector, the nearby irrigation sector and the tourism and services sectors. All this will reduce the tendency of population losses and its aging by contributing to the area dynamization.

ENVIRONMENTAL IMPACT

In addition, it is necessary to add the **environmental impact advantages** that have been evaluated in the framework of the Project, through the **Life Cycle Analysis (LCA)** methodology. LCA was made based on three interesting environmental indicators: **carbon footprint**, **terrestrial acidification** and **aquatic eutrophication**.

According to their **life cycle**, new MIX_Fertilizer are **environmentally more favorable**. The carbon footprint of the process has been **60% lower** than that of traditional fertilizers.

LIFE MIX_FERTILIZER CONCLUSIONS

A new system to enhance the digestate of pig manure generated in biogas plants has been successfully tested.

What economic advantages have these fertilizers shown?

New fertilizers have achieved **10% yield increase** in short cycle barley crops. In addition, they provide lower operation costs, since only a **single application** is necessary compared to traditional fertilizers.

What environmental benefits have these fertilizers shown?

The organic base of the new fertilizers contributes to improve the general **soil quality**. This feature is especially interesting for Castilla and León Region soils, for instance, where the prolonged and exclusively use of mineral fertilizers has impoverished soil. In addition, the pH of the new fertilizers is slightly acidic, which is also beneficial for basic soils, such as those from this Region.

In addition, the controlled release of nitrogen from the new fertilizers **reduces leachate losses** (aquifer contamination) or GHG **emissions**.

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