Project co-financed by the European Regional Development Fund

RE-LIVE WASTE- Improving innovation capacities of private and public actors for sustainable and profitable REcycling of LIVEstock WASTE

Project title and acronym	RE-LIVE WASTE
Work Package	WP3 Testing
Deliverable n. and title	D.3.6.1 Economic Evaluation Report
Responsible Partner	LA UNIÓ DE LLAURADORS I RAMADERS
Participating partners	University of Sassari; Cyprus University of Technology, Sarajevo Economic Regional Development Agency SERDA, University of Sarajevo – Faculty of Agriculture and Food Sciences
Main authors	José Castro León, Carla García Ibáñez
Reviewers	Michele Mario Gutierrez and Giovanni Ragaglia
Dissemination level	Partnership; JS

Project co-financed by the European Regional Development Fund

RE-LIVE WASTE

Table of contents

RE-LIVE WASTE- Improving innovation capacities of private and public actors for sustainable and profitable REcycling of LIVEstock WASTE 0

.... 0

INTRODUCTION 7

DESCRIPTION OF THE CONTEXT 8

MARKET STRATEGY 10

Common Analysis 10

How will you reach your Target Markets? 11

Bosnia-Herzegovina 11

Cyprus 11

Italy 11

Spain 11

Is your location a good location for your business? 11

Bosnia-Herzegovina 11

Cyprus 11

Italy 12

Spain 12

Who are the purchasers of your products? 12

Bosnia-Herzegovina 12

Cyprus 12

Italy 12

Spain 12

What is the size of the market in your country? Is it growing? 12

Bosnia-Herzegovina 12

Cyprus 13

Italy 13

Spain 13

What is (will be) your share? How will your share change over time? 13

Bosnia-Herzegovina 13

Cyprus 13

Italy ... 13
Spain ... 13
PRODUCT STRATEGY ... 15
Common Analysis ... 15
How do your products/services differ from the competition? ... 16
Bosnia-Herzegovina ... 16
Cyprus ... 16
Italy ... 17
Spain ... 17
Why will customers buy from you? ... 17
Bosnia-Herzegovina ... 17
Cyprus ... 17
Spain ... 17
What Position or Image will you try to develop or reinforce? ... 17
Bosnia-Herzegovina ... 17
Cyprus ... 18
Italy ... 18
Spain ... 18
How will products be packaged? ... 18
Bosnia-Herzegovina ... 18
Cyprus ... 18
Italy ... 18
Spain ... 18
PRICE STRATEGY ... 19
Common Analysis ... 19
Who are (will be) your largest competitors? ... 19
Bosnia-Herzegovina ... 19
Cyprus ... 19
Italy ... 20
Spain ... 20
How will your operation be different than your competitors? ... 20
Bosnia-Herzegovina ... 20
Cyprus ... 20

Italy 20
Spain 20
Is there anything about your business which insulates you from price competition? 21
Bosnia-Herzegovina 21
Cyprus 21
Italy 21
Spain 21
How will competition respond to your market entry? 21
Cyprus 21
Italy 21
Spain 21
Can you add value and compete on issues other than price? 21
Bosnia-Herzegovina 21
Cyprus 22
Italy 22
Spain 22
PROCESS STRATEGY 23
Technical details of the process 23
Common Analysis 25
Who are/will be your customers? 25
Bosnia-Herzegovina 25
Cyprus 26
Italy 26
Spain 26
What will be special or unique about this business in your territory? 26
Bosnia-Herzegovina 26
Cyprus 26
Italy 26
Spain 26
What is your experience with this type of business? 27
Bosnia-Herzegovina 27
Italy 27
Spain 27

ECOLOGICAL CERTIFICATION (ECOLABEL) 28
What is Ecolabel 28
Fertilizer Registration 28
Environmental Certification 29
Ecolabel Application 31
Ecolabel approval criteria 31
Required product information 34
Procedure for the development and revision of EU ecolabel criteria- 34
Preliminary report. 34
Proposal for draft criteria and associated technical report 35
Final report and draft criteria 36
Manual for potential users of the EU Ecolabel and competent bodies 36
Manual for authorities awarding public contracts 36
COST BENEFIT ANALYSIS (SPAIN MODEL) 37
Adopted methodology 37
Definition of Objectives 39
Methodology 39
Problems to be solved 41
Project identification 43
Project activities 44
Possibleinstitutions/companies responsible for implementation 48
Technical feasibility and environmental sustainability 49
Analysis of the demand 49
Tests carried out 51
Financial Analysis 54
Revenue / Sales 55
Investment 56
Loan Valuation 59
Production costs 59
Personnel costs 61
Opportunity costs 62
Profitability. Financial Projection 63
Economic conclusions 64

COST BENEFIT ANALYSIS (Bosnia -Herzegovina) 66
Process strategy 66
Local Comments 70
Financial Analysis 71
Revenue / Sales 71
Investment 72
Production costs 74
Personnel costs 75
Opportunity costs 76
Profitability. Financial Projection 77
Economic conclusions 78
COST BENEFIT ANALYSIS (Cyprus) 80
Process strategy 80
Technical details of the process 80
Main steps followed for struvite crystallization production. 82
Financial analysis 84
Revenues/Sales 85
Investment 86
Loan evaluation. 87
Residual value 88
Extra maintenance 88
Production costs 89
Transport costs 89
Consumables costs 89
Other production costs 90
Staff costs 91
External assistance services 91
Opportunity costs 92
Profitability-Financial Projection 93
Economic conclusions 94
References 96
COST BENEFIT ANALYSIS (Italy) 97
Introduction 97

Process strategy 98
Technical details of the process (Plant scheme) 98
Main steps 98
Financial analysis 102
Revenue / Sales 102
Additional income: 103
Investment 103
Loan valuation 104
Other consideration 105
Production costs 105
Personnel costs 106
Opportunity costs 107
Profitability. Financial Projection 108
Economic conclusions 108
Concluding remarks 113
COMMON RISKS AND ENTRY BARRIERS 114
SWOT analysis 114
Weaknesses 114
Threats 115
Strengths 115
Opportunities 116
KEY FACTORS 117
ANNEX 1: FINANCIAL TOOL 118

INTRODUCTION

This Economic Evaluation document includes several complementary documents that are necessary to assess the profitability and/or convenience of implementing this technology in the different European territories that need to improve the management of their livestock by-products.

One of the main documents included in this Economic Evaluation is the Cost-Benefit Analysis (CBA). In order to carry out this CBA, the parameters used and achieved in the 4 pilot plants developed in the 4 participating countries have been taken into account. Firstly, the Spanish case has been developed, which has served as a model to develop the other 3 cases. In 3 of the cases, an industrial scale projection of the pilot plants has been carried out according to the needs and appreciations of each of the territories, in one of the cases we have focused more on the improvement of the process and the optimization of costs. The aim was to cover the widest possible range of situations.

On the other hand, it was considered important to develop a reference model that could be adapted by any other project partner in their country or by any other actor interested in implementing an experience similar to the one developed. Each of the analyses is based on a different raw material (always with livestock manure) and, therefore, the financial and viability results are also different, although it can be seen, overall, that it is an efficient, profitable, and sustainable process.

In addition to this, and to improve this transferability to other territories, apart from the model developed in this CBA, a simple but very graphic and demonstrative financial tool is attached, where, by introducing the specific values of each territory, the profitability of the process is automatically generated.

This expert system (Excel workbook) is the one that has also been incorporated, with its relevant explanations, in the financial analysis of this document and will form part, together with this document, of the results of the project.

The other points previously developed in this Economic Evaluation document: market, marketing, eco-label, are common to the whole MED territory and have their own development for each of the partner countries of the project.

All these points consist, initially, of the common analysis that has been achieved thanks to the debates, shared documents and meetings between the whole Consortia. Meanwhile, the final part of these points consists of the qualifications and differences raised by each of the territories participating in RE-LIVE WASTE, which are logically due to the existing differences between the 4 territories and their own realities.

DESCRIPTION OF THE CONTEXT

The livestock production system, concentrated in certain areas, means that agricultural land does not have sufficient capacity to absorb the nutrients that this livestock activity generates naturally. This can lead to soil and water pollution. For this reason, it is necessary to establish action strategies to plan the management of this type of by-products in order to reduce the environmental impact that their excess may cause.

At present, most livestock farms are independent of agricultural holdings, which poses a challenge for the management of surplus excreta. This is aggravated in areas close to populations, generating environmental problems that have been recognized by the European Union (Directive 91/676/EEC on nitrates and Directive 2010/75/EU on industrial emissions.[1]

A classic solution is the agronomic use of slurry as a fertilizer. Such use is complicated by the concentration of livestock in some areas that produce a surplus in agricultural application and by the costs of handling and transporting the slurry. In many areas of high livestock density there is no land available that can receive significant volumes of manure without causing contamination of soils and aquifers. This is a complex problem that has to do with the location of the farms, but also with management strategies that cannot be unique.

As an example, in 2010 approximately 7.8% of manure production in the EU was processed, equivalent to a total volume of 108 million tons of manure per year, with 556,000 tons of N and 139,000 tons of P (Flotats et al., 2013). At least 45 different technologies for manure treatment are available (Foget et al., 2011).

The highest levels of livestock manure processing are observed in Italy, Greece and Germany, with 36.8%, 34.6% and 14.8% of their manure production, respectively.

The previous European Regulation on fertilisers (EC No. 2003/2002) did not contemplate struvite as a standard fertilizer. There are already proposals to incorporate struvite in the new Community Regulation on fertilisers, as is the case with the criteria proposed by the European Sustainable Phosphorus Platform (ESPP, 2015). In 2019, the European Commission extended the scope of the Regulation to fertilizer products based on secondary raw materials, resulting in a new EU Regulation No. 1009/2019. Article 42 of the Regulation provides that the Commission shall carry out an assessment to verify that these products (i) do not pose a risk to human, animal or plant health, safety or the environment and (ii) ensure agronomic efficiency.

Precipitated phosphate salts can now be legally used in the Netherlands, Belgium, Germany, France, Denmark and the United Kingdom. And these legislations set out criteria. As a general rule, the material must comply with maximum limit values for inorganic contaminants, biological pathogens

1

and minimum nutrient contents, while some countries also have maximum limit values for organic contaminants (PAH, PCDD/F, MBM, aldrin, dieldrin, endrin, isodrin, DDT + DDD + DDE and mineral oil) depending on the dry matter or nutrient content of the fertilizer. In addition, there is a cross-border mutual recognition initiative for struvite between the Netherlands, Belgium and France (De Clerq et al., 2015).

The Commission's Joint Research Centre (JRC) has recently published a specific assessment of the binding criteria proposed for the inclusion of struvite and other precipitated phosphate salts in the new fertilizer regulation.) The Commission is preparing a technical annex to the Regulation, the analysis of which is under way. The JRC report agrees with the Platform's recommendations to establish, for pure struvite, a minimum phosphorus (P_2O_5) content in dry matter (the JRC proposes 16%) or an upper limit of organic matter (the Platform proposes 2%). In addition, EU fertilizer products must comply with the REACH Regulation (EC) No 1907/2006). This Regulation addresses the manufacture, use and marketing of chemical substances and mixtures, and their potential impacts on both health and the environment.

Finally, there is the application of the *End-of-Waste (*EOW) principle or procedure for a substance to be catalogued as a by-product and not as a waste. The guidelines set out in Law 22/2011 of 28 July on waste and contaminated soil must be complied with. However, there is no specific procedure for private individuals to apply for the EOW concept, but rather each country takes the decision, by means of a ministerial order. The export of the material as a by-product will only be allowed (i) if the country of destination accepts it as such; otherwise, it will be exported as waste; and (ii) those substances that are declared as by-products comply with product-specific regulations (e.g. REACH, fertilizers, etc.).

The average expenditure on fertilization on farms in the EU is between 1% and 12% of total costs (Wijnands and Linders, 2013). This expenditure is relatively high for farms producing specialized crops such as fruit and vegetables, almost 12%. Total fertilizer consumption has fluctuated over the last two decades with a sharp decline towards 2008 and a recovery that has tended to stabilize in recent years. In terms of nutrients, in 2017, consumption was 1 million tons of N, 436 thousand tons of phosphorus and 388 thousand tons of potassium. There is a demand for ternary and binary complex fertilizers of about 1,5 million tons (2016 data), half of which is supplied by imports.

Thanks to the implementation of pilot and demonstration activities like this, livestock by-products can be transformed from a disadvantage (environmental problem and management costs) into a valuable resource for the agricultural sector. The evaluation of the pilot actions allows to identify the strengths of the tested solutions.

MARKET STRATEGY

Common Analysis

The common points for the MED territory regarding the market opportunities that this technology represents as a solution to the problem of sustainable management of livestock by-products are:

- ✓ It is a valid and appropriate project for the enormous potential of organic farming in the territory. The organic struvite market arises from the growing interest in organic products;
- ✓ Fertilizer regulations will increasingly favor the reuse of nutrients. European policies and strategies are focused on the replacement of mineral fertilizers with organic fertilizers. Some examples are: "Green Deal", "Farm to Fork", "Bioeconomy", "Circular Economy". All these strategies and concepts advocate the substitution of mineral fertilizers, the valorization of biological by-products and an increase in sustainable agriculture;
- ✓ Today, farmers are obliged to manage their by-products in another, more sustainable way than the one they are currently using. With this project they are learning the benefits of struvite recovery to more easily meet the requirements of the strict EC Nitrate Directive;
- ✓ Fertilizer recovery improves the multifunctionality of the agricultural value chain with increases in income. Both the livestock and agricultural markets are favored by the implementation of this technology. Moreover, these are strategic sectors in rural areas. This project mitigates the rural depopulation and social abandonment of certain territories. In short, it promotes a circular economy adapted to the demands of society and a sustainable approach to livestock farming, improving its social image;
- ✓ The regulation of the product as FDR (End of Waste) will allow a better approach to the final customers. These include farmers, fertilizers companies, research institutes on biofertilizers production, gardeners, landscapers, floriculture and forestry companies and producers of ornamental crops;
- ✓ The technology adopted by the RE-LIVE WASTE project makes the product unique. In fact, this technology offers the possibility of producing a fertilizer on site from waste products (in our case related to pig slurry), opening up a new market that currently does not exist in our region;
- ✓ The biofertilizers business is a multifunctional effort based on a simple technology easily managed by the rural community of our region. It is an organic fertilizer that has proven to be effective and uses by-products of wastewater treatment, in our case pig slurry;
- ✓ The technology applied will contribute to the circular economy of the territory: The product is a slow-release fertilizer with a low level of solubility and an appropriate N and MgO content that will add additional value to the crops. These factors will add motivation to farmers within the new CAP strategies.

The following are the different country-specific market views of RE-LIVE WASTE

How will you reach your Target Markets?

Bosnia-Herzegovina

Mainly through specialized TV shows on agricultural production. In addition, the results of the Project and product characteristics will be presented (of course, with the permission of the project consortia) on some professional conferences. In doing so, events that are dominated by the presence of farmers will be selected.

Cyprus

Social media, workshops, educational programs, TV appearances in environmental programs, fertilizer sale points as service centers, preempt and improve regulations and incentives.

Italy

Advertising in specialized trade magazines and dissemination to the main local wholesalers should be sufficient to have good results.

Spain

Professional agronomic events in big scale, social networks and media campaigns.

Is your location a good location for your business?

Bosnia-Herzegovina

Yes, because pilot phase of struvite production is located close to biggest town which is very well connected with other part in B&H.

Since Sarajevo is the capital, the presence of various governmental, non-governmental organizations and the pronounced fluctuation of people will contribute to an easier spread story of the product quality.

In addition, many people around have small farms and greenhouses (recently, urban agriculture is getting up to date.

Cyprus

Cyprus market is small, but it could be the perfect location for this kind of business due to its strategic location, which is close to Middle East, Africa, and Asia.

The island has one of the lowest corporate tax rates in EU at 12,5%, double taxation treaties with 64 countries across the globe, a highly educated workforce, and a sophisticated transport and logistics infrastructure

Italy

Given the regional conformation of the sector, the production of struvite from livestock waste must necessarily take place near the districts of cattle and pig breeding. This production often coincides with the areas with the highest consumption of fertilizers.

Spain

Many people around the center of Valencia have small farms and practice urban agriculture even in the city.

Who are the purchasers of your products?

Bosnia-Herzegovina

Potential markets for struvite include the natural foods and organic industry and backyard gardeners interested in environmentally friendly products. Due to its lower solubility level, struvite is considered a slow release fertilizer.

Cyprus

Farmers, wholesale fertilizer companies, gardeners, landscapers, turf growers, floriculture, silviculture, and ornamental crop growers. Perhaps research institutes that would like to perform experiments on the biofertilizers produced

Italy

Farmers, wholesale fertilizer companies, gardeners, landscapers, turf growers, as well as ornamental crop growers and in lesser degree academic and institutes doing agronomic research.

Spain

In the region: a) farming cooperatives b) individual organise farmers c) small and business enterprises engaged in the bio-fertilising industry that could be interested in completing their range of products on sale.

What is the size of the market in your country? Is it growing?

Bosnia-Herzegovina

Official data on the consumption of mineral fertilizers do not exist; it is estimated of about 170.000 tons. Most of fertilizers are imported from EU countries (mostly from Croatia) and dominant fertilizers are NPK and KAN. Intensification of agricultural production will require additional quantities of fertilizers (EU consumption of pure nitrogen and phosphorus is from ca 30 kg/ha in Portugal to more than 140 kg/ha in Netherland.)

Cyprus

The size of the farmer sector in Cyprus based on data from 2015 includes 108.600 ha arable land, 14.196 registered farmers, and the cost of fertilizers are 19.291.000 euros per year. Agricultural production has been on an increasing trend from 2014.

Cyprus has a small domestic market for fertilizers' business, compared to the excess of manure that it produces, however the interest in innovative and sustainable methods in agriculture is growing.

Italy

In Sardinia, a general increase in consumption is observed in the fertilizer market.

From the available data it can be observed that the use of fertilizers between 2013 and 2015 has increased by +65% while that of fertilizers has been increased in the same period by +20%.

Spain

Comunitat Valenciana is the Spanish region with highest actual and potential growth in organic farming, with presently around 2,000 individual customers, with a growth of over 20% in the last two years

What is (will be) your share? How will your share change over time?

Bosnia-Herzegovina

Initially, due to limiting capacity and small production of struvite its share on B&H market will be negligible.

Increasing marketability of struvite could be happen in the near future, especially taking into account a relatively high interesting of farmers who keeping livestock in this type of the business expressed during previous period (period of the Project presentations of stakeholders in B&H).

Cyprus

Initially, the overall market share of the company will be low since it will take time for general public to accept these fertilizers. As time goes by and with sufficient promoting and proof of the benefits of these biofertilizers we expect it to increase.

Italy

As a research organization we are unable to evaluate this. The figure will depend on the size of the company that will invest in this technology.

Spain

Once the business is stablished it has the potential to become one of the first local suppliers of recovered struvite in the Comunitat Valenciana. A significant demand for organic fertilizers exists in the Alto Palancia, Camp de Turia, Utiel-Requena and in the whole Castellon province.

The market share has potential to settle and grow but it will depend on the agreements to be built among livestock farmers and agricultural growers, with participation of the farming unions and coops.

PRODUCT STRATEGY

Common Analysis

The chemical reaction produces a struvite-enriched precipitate of a muddy state. By filtering the sludge into drainage bags, after 48 hours of drying, a light brown solid material is obtained. The analyses carried out indicated that the dry MAP has a composition in which (in addition to the basic components, i.e. ammonium, phosphorus and magnesium) it also contains natural trace elements and easily assimilated organic substance. These characteristics place MAP as a ternary organo-mineral fertilizer of slow release.

The product obtained is characterized by: i) stability, with no danger of nitrogen volatilization and no emission of bad odors; ii) high concentration of nutrients (N, P and organic matter) and presence of trace elements; iii) natural origin; iv) low volatility; v) low solubility; vi) high bioavailability; and vii) adaptability to other livestock waste management processes.

The production technology adopted by the RE-LIVE WASTE project makes the product unique in the market. In fact, this technology offers the possibility of producing a fertilizer on site from organic waste, opening up a new market that currently does not exist in European regions.

Obtaining a new ingredient for fertilizer products will stimulate innovation to develop nutrient release formulations in conventional water-soluble phosphoric fertilizers or by combining struvite with other component materials in a single product (e.g. as an additive to compost).

Legal approval of struvite will promote greater competition between fertilizer manufacturers and blending companies with possible effects on the purchase prices of fertilizer materials by farmers. Finally, the production of fertilizers from secondary raw materials produced locally in Europe will reduce the susceptibility of the European agricultural sector to fertilizer price volatility due to possible external geopolitical tensions and the depletion of readily available high-quality phosphate rocks.

In addition to the total phosphorus content, its solubility provides an indication of the P available in fertilizers. The raw material for the production of most mineral P fertilizers is apatite, which is present as phosphate rock in nature. This material can be used directly as a fertilizer, but due to its low solubility, the phosphorus available to the plant is low. By crushing, heating and acidifying the rock, the solubility of P can be increased.

The key element of a business model is to provide a circular approach to avoid that gap between farmers and the market. The system can take advantage of the proximity to the farms in the region. There are many competitors in the biofertilization sector, both large corporations and small businesses.

In general terms, the materials marketed at the exit of the precipitation-drying plant will be considered as raw materials for further processing, e.g. in the form of bulk mixtures (for mixers) or physical N/P/K compounds (for fertilizers manufacturers). Direct application of marketed products could also be practiced, but the mixtures and compounds will represent the bulk of the actual soil application. Easily removable drainage bags will facilitate the sale of the product.

In addition, an ecological image will be used on the product packaging: the recycling symbol and the EC fertilizer label indicating the product's strengths for your guarantee.

The image to be developed will be that of farmers involved in actual production for agronomic purposes related to phosphorus recovery and nitrogen removal. This social, organic and circular approach will have to be projected in the image of the product. The product should have promotional messages of the type:

- ✓ We produce a natural fertilizer that recovers nutrients and transforms them into agricultural value
- ✓ For a circular approach to sustainable livestock farming
- ✓ Create and manage your own fertilizer in a sustainable way

The basic ideas are in the message, as a non-synthetic fertilizer, based on recovery and its agronomic value with a circular approach.

It can be complemented with workshops to launch the new product, with visits to the facilities, to make the product known, to offer security to livestock farmers and fertilizer companies. Additionally, we will attend exhibitions and fairs.

Social networks (FB, Instagram and Twitter) and a blog are basic to multiply the network of contacts and present it as an associative project.

How do your products/services differ from the competition?

Bosnia-Herzegovina

Besides of relatively high content of P struvite contains N and MgO which adds extra value of the product. Additionally, solubility of P in struvite is lower comparing to "conventional" fertilizers. Thus, struvite could be used as slow release P fertilizers-economical, ecological and extra nutrients advantages. This benefit will motivate eco-conscious farms to start using struvite.

Cyprus

The treatment technology that is used (anaerobic digestion plus dark fermentation, separation with centrifuge separator and filter bags, composting as the treatment of solid streams, struvite crystallization unit plus SBR for the liquid streams and biogas trickling filter and biofiltration hybrid system for the treatment of the biogas and the produced gaseous pollutants respectively) make the product of high purity and quality (increased percentage of active ingredient per product weight).

In addition, since our plant are zero waste/zero emissions we will have less trouble getting permits to build them in any location (urban or industrial).

Italy

This type of fertilizer obtained from zootechnical slurry can boast a mark of eco-sustainability.

Spain

The ultimate treatment technology will contribute to the circular economy project. The P fertilizer releases phosphorus at a slow rate compared to conventional fertilizers. Also, the content of N and MgO will add extra value to the product. This fact will motivate farms to start using struvite and be eco-conscious

Why will customers buy from you?

Bosnia-Herzegovina

Potential market for struvite includes the natural foods and organic industry and backyard gardeners interested in environmentally friendly products. Due to its lower solubility level, struvite is considered a slow release fertilizer. Additionally, there are no any similar product (fertilizer) as potassium ammonium phosphate or potassium magnesium phosphate, which will be recognized as ecological friendly fertilizers on B&H market.

Cyprus

These products will fulfil the end-of-waste criteria, hence, they can be used as added-value materials and also, as safe products that can be placed on the market, according to the Regulation related to fertilizers.

Spain

There are not any similar bio-fertilizers with this phosphoric component and it is considered a slow release fertilizer with a low solubility level.

Eco-conscious market for struvite relies on the growing interest in environmentally friendly products.

What Position or Image will you try to develop or reinforce?

Bosnia-Herzegovina

The product will be promoted as ecological friendly product that can be used with the same efficiency as conventional fertilizers but with less negative environmental effects.

Cyprus

An eco-friendly image with the recycling sign, including the EC fertilizer label and indicating the strengths of the product that is a slow release fertilizer.

Italy

Undoubtedly it should be packaged and advertised with references to the eco-sustainable origin of the product and providing data on the reduction of nitrate pollution obtained through the process.

Spain

An eco-friendly image will be used in the packaging: the recycling sign, the EC fertilizer label and indicating the strengths of the product itself so it can be guaranteed.

A main image would be that of farmers involved in the production of a clean and effective output for agronomic purposes which related to phosphorus recovery and nitrogen removal.

How will products be packaged?

Bosnia-Herzegovina

In the beginning, the product will be packaged in small quantities (up to 1 kg) suitable for small gardens and flowers producers. By intensifying production, the product will seek to be marketed in parts of B&H that are classified as ecologically vulnerable areas.

Cyprus

In 25 kg bags, 50 kg bags, big bags to be shipped as break bulk or in containers. The labelling and packaging of products and substances in EU is regulated by CLP Regulation (EC) No 1272/2008.

Italy

In consideration of the territorial market already described, the packaging of the product is expected to be:

- ✓ For specialized companies: 25-50 Kg bags
- ✓ For hobbyist: 1-5 kg containers

Spain

There are two ways of packing. First, by using the draining bags that can be removed and facilitate commercialization. Secondly, on bulk by using the output coming out from the centrifugation process.

PRICE STRATEGY

Common Analysis

The final price of the struvite precipitation obtained depends on the degree of purity tested on the plant. The process gives the opportunity to have a two-level strategy with premium and regular quality, which of course must be standardized by the strict quality control of the process (it also depends on the cost of the reagent dosage).

P-fertilizers sold to specific sectors (e.g. use of fertilizers in horticultural applications, home gardening and growing media) may be associated with higher sales prices, and depend on a market that creates confidence for the company.

The value of struvite will vary depending on fertilizer costs and niche markets for struvite, such as turf fertilization. The paper by Li et al (2019)[2] considers prices between 300 and 800 USD/TN. Westerman et al (2010)[3] consider 330 USD/Tn. SERECO's experts (project partners) propose a valuation between 200 and 400 euros/t. The price obtained in the struvite business model will depend on the degree of purity in this precipitate of the solid fertilizer obtained.

Who are (will be) your largest competitors?

Bosnia-Herzegovina

Given the regional conformation of the sector, the production of struvite from livestock waste must necessarily take place near the districts of cattle and pig breeding. This production often coincides with the areas with the highest consumption of fertilizers.

Cyprus

OSTARA with Crystal Green. Crystal Green is sustainably produced by Ostara using nutrient recovery technology that combines phosphorus, nitrogen, and magnesium into pure crystalline granules.

Suez with Phosphogreen. Suez SA operates largely in the water treatment and waste management sector. Phosphogreen is a phosphorus recovery process based on a precipitation-crystallization reaction. The struvite that is produced from that technology is used as agricultural fertilizer.

---

[2] Li, B., Udugama, I. A., Mansouri, S. S., Yu, W., Baroutian, S., Gernaey, K. V., & Young, B. R. (2019). An exploration of barriers for commercializing phosphorus recovery technologies. *Journal of Cleaner Production*, *229* 1342-1354.

[3] Westerman, P. W., Bowers, K. E., & Zering, K. D. (2010). Phosphorus recovery from covered digester effluent with a continuous-flow struvite crystallizer. *Applied engineering in agriculture*, *26*(1), 153-161.

Veolia with Struvia. Veolia Water Technologies is a world leading company which specializes in water and wastewater treatment solutions for industrial clients and public authorities. It has over 80 business units worldwide. Struvia- Phosphorus Recovery and Harvesting uses a patented mixer, TurboMix, in combination with lamella settlers to produce and separate struvite crystals from the wastewater within a single reactor with a small footprint, making it an economical phosphorous recovery process.

Italy

The biggest competitors will be local importers of multinationals.

Spain

There are competitors in the bio-fertilizing sector which has considerably grown in the Valencia region, including big corporations and small businesses. However, the struvite recovery operations from WWTP is not developed in the region.

How will your operation be different than your competitors?

Bosnia-Herzegovina

In the current situation, many small firms are engaged in the distribution of mineral fertilizers. Some of them also distributed processed manure (dried). All of these are different products compared to struvite, which still eliminates competition.

Cyprus

The pilot plant of CUT uses state of the art technology to produce struvite. Through the combination of a struvite crystallization reactor with a sequencing batch reactor, very high removal efficiencies of the pollutants can be achieved, while nutrient recovery is also performed, so the specific technology constitutes the best option for the treatment of liquid livestock waste streams. The phosphates from the UF permeate are higher than from municipal wastewater, so the struvite produced has a stoichiometric ratio close to the pure struvite.

Italy

It is expected that the choice of local products is predominant by the possible buyers of the product

Spain

This project is really focused on struvite recovery and production, so we believe that the service and product supplied are unique in the region. Cooperatives enter the business; they can share the added value of struvite marketing.

Is there anything about your business which insulates you from price competition?

Bosnia-Herzegovina

Market strategy will be based on innovative characteristics of the product (slow release of nutrient into soil). Similar product, on B&H market, are not existing yet.

Cyprus

The innovative fertilizer that promotes increased use of recycled nutrients and aids the development of the circular economy in Cyprus.

Italy

Sardinia is an island. Promoting on-site fertilizer production should generate a reduction in the production costs compared to the competition, because transport costs are reduced.

Spain

Proximity to customers, as the business is supported by an agricultural research institution and a farming organization.

How will competition respond to your market entry?

Cyprus

They will emphasize on the strengths and opportunities of their products in terms of quality and quantity.

Italy

This will depend on the amount of entry into the market. If production is on a small scale, competitors will not react. However, the entry of new alternative products usually generates a general reduction in prices.

Spain

A clarification of the legal status of struvite will open the door to a great number of potential competitors. The nature of the project opens the door not to create competitors but to provoke spillover effects in the cooperatives and livestock farms where the same project's partner can be involved.

Can you add value and compete on issues other than price?

Bosnia-Herzegovina

The product marketing it will also be based on its origin; namely on the conversion of an environmentally questionable by-product in livestock production (manure) into a new fertilizer.

Cyprus

The high quality of the product as the company will strive to produce an EC fertilizer.

Italy

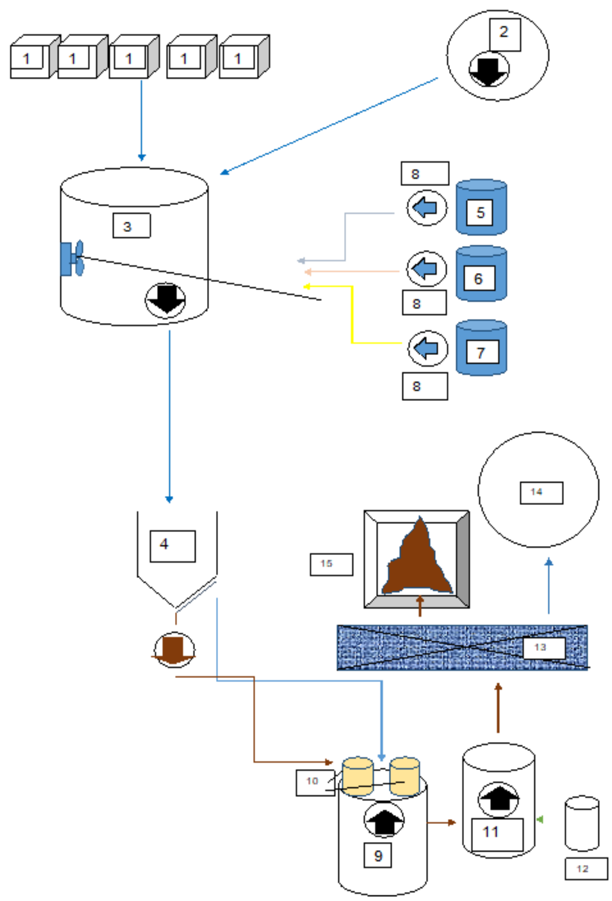
Since it is an eco-sustainable fertilizer it is probable that the market will respond to the marketing with an assessment of demand in a positive sense that would have positive effects on the sale price.

Spain

Proximity to customers mean better service so the real demands and effectiveness of the fertilizer can be tested daily to modulate the kind of struvite to be marketed and even adapted to potential cooperatives and other kind of customers.

PROCESS STRATEGY

Technical details of the process



1. Incoming slurry storage tank
2. Incoming slurry tank without pre-treatment
3. Reaction tank.
4. Fluidized bed settler.
5. Phosphoric acid deposit
6. Magnesium chloride tank
7. Sodium hydroxide tank
8. Dosing pumps
9. Temporary storage of the treated digestate.
10. Drainage bags.
11. Polyelectrolyte preparation plant and centrifugal loading.
12. Polyelectrolyte charge.
13. Centrifuge.
14. Centrifugal waste storage tank
15. Struvite solids on the platform.

Below is a functional description of the process units with an indication of some performance characteristics of the electromechanical units:

Storage of influential manure through small and safe tanks.

The pre-treated/untreated slurry is transported to the pilot plant by tank truck equipped with a pump and the necessary safety devices. Using the supplied pump, the suspension is loaded into 1 m^3 tanks from which the suspension is transferred to the pre-treatment and reaction unit. The project envisages that there may be other sources of slurry and other organic products that will have to be stored appropriately.

Pre-treatment (stripping), reaction, crystal growth and maturation

The pre-treatment consists of the extraction of CO_2/NH_3 operated in a stainless-steel circular plant tank (no. 3 in the Figure). The treatment is carried out through agitation by means of a vertical shaft submersible mixer equipped with an electric motor. The degassed suspension is subjected to a precipitation reaction through the dosage of the chemical products, whose quantity and speed of supply are established according to the ammonia value (mobile meter) and the pH (sensor fixed in the tank). Once the reaction reaches the stage where the formation of the crystalline nuclei by oversaturation occurs, the batch loading of the suspension resulting from the precipitation reaction into the sedimentation unit is carried out by means of a submersible pump.

Sedimentation/ precipitation of O-SEP

The fluidized bed settler consists of a truncated conical cylinder made of stainless steel or FRP (fiberglass reinforced polyester resin). The settler (no. 4 in the figure) is divided into three sections: a) An internal part represented by a vertical cylinder fixed with supports to the walls of the outer cover. The pipe is open at the top and at the bottom; b) an external cylinder made of steel or FRP. Outside the cylinder there is a circular channel with a 3° slope in the direction of the drainage pipe equipped with a chute; c) a truncated conical bottom which has an external wall with a resistance of 60° with respect to the horizontal axis. The bottom outlet is connected to a mohno pump.

Temporary storage of the treated suspension (liquid effluent)

The effluent from the treated struvite precipitation is discharged by gravity, through a pipe in the tank (no. 9 in the Figure). A mobile ammonium sensor will measure the NH_4^+ concentration and directly evaluate the efficiency of the process. The effluent is sent with a submerged pump to a) a storage tank already in use at the plant for the collection and dispersion of treated liquids by hydraulic connection with existing pipes or b) to the pre-treatment tank for recirculation.

Tank for the preparation of O-SEP with polyelectrolyte before centrifugation.

A mohno pump is hydraulically connected to the bottom of the settler with a flexible corrugated pipe that feeds a) a polyelectrolyte preparation tank ("homogenization and centrifugal loading tank") or, as an alternative, b) a filtering system with drainage bags placed on the tank in the previous section. The polyelectrolyte preparation tank (no. 11) is where the homogenization and dilution of the precipitate is carried out and is hydraulically connected to a centrifugal separation station by means of a submerged pump or mohno.

Dehydration of O-SEP by centrifugal separator.

The "Pieralisi baby" centrifugal separator (no. 13 in the figure). Under the centrifuge, there is a trolley for the collection of the precipitate containing struvite.

Drainage bags

The sludge filtering system, located on tank no. 9, consists of polypropylene drainage bags housed in a metal support structure that rests on a special grid. The bags with the dewatered O-SEP will be manually removed and stored properly. The drainage of the filter bags falls through the grid into the underlying tank No. 9.

Reagent dosing station

The reagents required for the precipitation reaction are stored in small tanks (no. 5, 6 and 7) which are located in the reagent dosage area under the existing roof and on a concrete platform. The reagents used are: - Phosphoric acid (H_3PO_4), average purity 73%; - Magnesium oxide (MgO), average purity 47%; - Sodium hydroxide (NaOH), minimum purity 30%. All the above reagents are supplied in liquid form. A dosing pump with manual flow adjustment and flow rate indication on a screen-printed analogue scale is connected to each tank. The flow rate will vary between 130 and 2200 l/h depending on the test conditions.

Common Analysis

Normally the precipitation and drying will be carried out by the same company and in the same facility. From the production and drying plant and meeting the criteria for an EU-marked (non-waste) fertilizer component, the product could be placed on the internal market. Alternatively, and perhaps more normally, it may be marketed to fertilizers blending companies or manufacturers, as an ingredient, by-product or under the national EOW criteria.

Another possibility is that all the agents involved can be from the same company, although in this case we will be based on a livestock company or association of livestock farmers. For example, a company could act as a supplier of the raw material to its own manufacturing sites, and sell its own products through its own distribution system, including the provision of services to farmers such as soil sampling, agronomic analysis and, in some cases, direct application to the field. Companies will have varying degrees of integration along the value chain. When looking at the European market in particular, the most common organization would be a separation between the fertilizer's manufacturers and the distributors/importers, which in turn are in many cases the companies of the mixers themselves.

Who are/will be your customers?

Bosnia-Herzegovina

Initially and primarily, costumers of the product will be owners of small house farms orientated on vegetable and flowers production. In the first phase, customers will be selected in Sarajevo Kanton, area with the highest number of smallholder farmers as well as area which is ecological vulnerable. Additionally, in this area pilot plant is installed so marketing of the product will be easier.

Cyprus

Farmers, wholesale fertilizer companies, gardeners, landscapers, turf growers, floriculture, silviculture and ornamental crop growers. Perhaps research institutes that would like to perform experiments on the biofertilizers produced.

Italy

It is possible to hypothesize that the stakeholders of this fertilizer will be the agricultural producers of the horticultural and floricultural sector, in particular companies that practice greenhouse crops.

For second instance, however, it is also possible to imagine customers in the hobby sector, both for gardening and for horticultural self-production

Spain

Once the legal status for end-of-waste is achieved with a new EU regulation, the final costumers will include farmers, fertilizer companies and research institutes on biofertilizers produces, gardeners, landscapers, floriculture companies, silviculture and ornamental crop growers.

They are based in the surrounding Mediterranean region, but struvite produced could be exported outside the region.

What will be special or unique about this business in your territory?

Bosnia-Herzegovina

This is the first operating unit that is involved in struvite production and distribution.

This technology offers the possibility of producing on site a fertilizer starting from waste products, opening a new market that does not currently exist in the region

Cyprus

Agriculture in Cyprus is rapidly diversifying and modernizing with greater input from scientists and researchers with innovative thinking.

Italy

The production technology adopted by RE-LIVE WASTE project which offers the possibility of producing on site a fertilizer starting waste products, opening a new market that does not currently exist in our region.

Spain

The production technology adopted by RE-LIVE WASTE project makes the product unique. In fact, this technology offers the possibility of producing on site a fertilizer starting from waste products (in our case related to swine slurry), opening a new market that does not currently exist in our region.

What is your experience with this type of business?

Bosnia-Herzegovina

In territory of B&H, there is nobody who is involved in this type (this type of fertilizers) of business. Similar business operating units (subjects involved in distribution of "conventional" mineral fertilizers like NPK and Calcium ammonium nitrate are targets groups of the projects). Their involvement will be crucial in the first phase of the product marketing.

Italy

As a University, there is no direct involvement in business, but there has been involvement in activities of RELIVE WASTE project.

Spain

The business is a multi-factor effort based on a simple technology easily managed by the rural community in our region. It produces an organic fertilizer that has shown its effectiveness and makes uses of sub products of wastewater treatment, in our case, swine slurry.

ECOLOGICAL CERTIFICATION (ECOLABEL)

What is Ecolabel

Established in 1992 and recognized across Europe and worldwide, the EU Ecolabel is a label of environmental excellence that is awarded to products and services meeting high environmental standards throughout their life-cycle: from raw material extraction, to production, distribution and disposal. The EU Ecolabel promotes the circular economy by encouraging producers to generate less waste and CO2 during the manufacturing process. The EU Ecolabel criteria also encourages companies to develop products that are durable, easy to repair and recycle.

The EU Ecolabel criteria provide exigent guidelines for companies looking to lower their environmental impact and guarantee the efficiency of their environmental actions through third party controls. Furthermore, many companies turn to the EU Ecolabel criteria for guidance on eco-friendly best practices when developing their product lines.

The objectives of the Ecolabel are:

- ✓ The manufacturer demonstrates voluntary compliance with a number of environmental requirements applicable to the product carrying it.
- ✓ The consumer is able to identify more environmentally sustainable products.

In our case, once the experimental phase of our product has passed and before applying for the Ecolabel, we must tackle two main stages. Firstly, we must study the steps necessary to <u>register the new fertilizer</u> and secondly, we must consider <u>voluntary certifications that validate respect for the environment</u>.

Fertilizer Registration

First of all, our product must be registered so the requirements for the certification of manufacturers of these products, currently regulated by the R.D. 506/2013 on fertilizer products, must be followed.

It should be noted that European legislation is still evaluating the inclusion of phosphorus recovery products such as struvite in Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down provisions for the placing on the market of EU fertilizers products.

Royal Decree 568/2020 also approved a new regulation on the marketing of fertilizers in the European Union which prohibits the certification of fertilizers that are not accredited with UNE-EN ISO/IEC 17065:2012 "Conformity Assessment. Requirements for bodies that certify products, processes and services".

The production and distribution process must consider the following requirements for the marketing of the new fertilizer:

- ✓ Being established in the EU;
- ✓ The installations must comply with RD 506/2013 on fertilizer products;
- ✓ The product complies with the regulations and is supplied with identification and labelling information;
- ✓ Evidence of the veracity of the information is available;
- ✓ As raw materials of animal origin are used, it must be ensured that the requirements of EC Regulation 1069/2013 are met;
- ✓ Application of the REACH regulation and providing the distributor with a safety data sheet;
- ✓ Comply with requirements on quality control and product traceability.

Of course, this fertilizer must be labelled. The following rules should be taken into account:

- ✓ The labels or indications printed on the packaging containing the data referred to in Annex II of Royal Decree 506/2013 must be placed in a clearly visible place;
- ✓ If the information is not printed on the package, the labels must be attached to the package or its closure system. If the closure system consists of a seal or fastening, it must bear the name or mark of the packer;
- ✓ The labelling must be and remain indelible and clearly legible;
- ✓ In the case of bulk fertilizer products, the goods must always be accompanied by a copy of the accompanying documents. This copy of the documents must be accessible to the inspection bodies;
- ✓ The compulsory indication of the manufacturer of the product refers to the person responsible for placing it on the market, and must specify whether he is a producer, importer, packer, etc.;
- ✓ The label, the indications on the packaging and the accompanying documents must be in at least the official Spanish language of the State.

Environmental Certification

All products, and also the manufacture of our fertilizer from phosphorus recovery have an impact on the environment. Although the circular approach makes it easier to reduce the impact, it is important to ensure this. Environmental product labels provide evidence that measures have been taken to minimize the adverse effect on the environment.

The European Platform on Sustainable Phosphorus (ESPP) has suggested the development of Ecolabels for this type of fertilizer, as a product group to which the EU eco-label regulation 66/2010 may apply. This would allow their use as raw materials for organic farming as slurry from intensive livestock farming is currently not covered by Annex I to Regulation (EC) 889/2008 on organic production. On the other hand, AENOR has approved the UNE 142500 Standard regulating fertilizers, amendments and cultivation substrates applicable in agriculture, which gives additional guarantees to farmers, and which could include struvite at some point.

The idea is to evaluate voluntary and mandatory standards that can bring value and safety to our product. This allows us to generate confidence in customers and in the whole environment related to the company, since it will facilitate the successful achievement of the strategic objectives in terms of commitment to the environment. This includes a plan with objectives, goals, processes and activities. Everything aimed at protecting the environment:

- ✓ Reducing CO_2 emissions. These basically have to do with energy consumption.
- ✓ Reduce process costs, in terms of reagents, to improve efficiency.

The following levels of voluntary certification can be considered:

A first level would be that derived from the implementation of the ISO 14001 standard and an Environmental Management System (EMS). Complying with an EMS standard will reinforce the image of the entity by projecting its concern for the ecosystem, helping to identify and prevent risks that may occur internally while the company is carrying out its activity.

In fact, the whole project must be improving energy efficiency, in the costs of reagents and in the reduction of nutrients, which is manifested in goals that must be incorporated into the Environmental Management System.

With the advice of a certifying body, the following steps will be taken

- ✓ Preliminary evaluation;
- ✓ Preparation of documents;
- ✓ Initial evaluation;
- ✓ Implementation of improvements and main evaluation;
- ✓ Issuance of the certificate to the company;
- ✓ Monitoring.

A second level, after the implementation process of the Environmental Management System, will evaluate other certifications such as those derived from the ISO 14020:2000 Standard that establishes the guidelines for the development and use of environmental labels and declarations:

ISO 14021:2016 describes the environmental terms together with the conditions for their use; a specific evaluation and verification methodology, without modifying any of the information on environmental labelling required by law.

The ISO 14025:2006 Standard presents quantified environmental information on the life cycle of products to enable comparison between products that fulfil the same function.

Finally, the ISO 14040:2006 Standard covers two types of study: life cycle analysis (LCA) and life cycle inventory (LCI), techniques developed to better understand and address the environmental impacts caused by products.

Ecolabel Application

The application must be submitted to the competent body in one of the Member States of origin. If the product originates outside the European Community, the application may be submitted in any of the Member States in which the product is to be placed on the market.

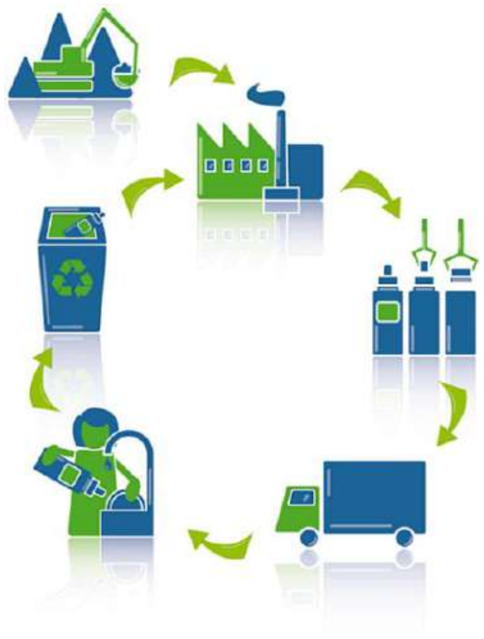
The competent body to which an application is made will charge a fee based on the actual administrative costs of processing the application. This fee shall not be less than EUR 200 or more than EUR 1,200.

In the case of small and medium-sized enterprises (SMEs) and micro-enterprises as defined in Commission Recommendation No 2003/361/EC of 6 May 2003 (OJ L 124, 20 May 2003, p. 36) and operators in developing countries, the maximum application fee shall not exceed EUR 600. In the case of micro-enterprises, the maximum application fee shall be EUR 350.

The annual fee is optional, depending on the Member State. For example, in Spain the option of not charging an annual fee has been adopted.

Ecolabel approval criteria

To qualify for the EU Ecolabel, products must comply with a tough set of criteria. These environmental criteria, set by a panel of experts from a number of stakeholders, including consumer organizations and industry, take the whole product life cycle into account - from the extraction of the raw materials, to production, packaging and transport, right through to your use and then your recycling bin.



Ecolabel Life Cycle

This life cycle approach guarantees that the products' main environmental impacts are reduced in comparison to similar products on the market. Fitness-for-use criteria also guarantee good product performance.

The label has been awarded to thousands of different products across Europe, including soaps and shampoos, baby clothes, paints and varnishes, electrical goods, and furniture, as well as services, like hotels and campsites.

In our case, the products that are most related and have already achieved their Ecolabel are related to the gardening sector and are within the categories of Soil amendments and cultivation substrates.

In both cases the main technical criteria required (serve as a reference) are.

Where appropriate, testing and sampling shall be carried out in accordance with test methods established by Technical Committee CEN 223 "Soil improvers and growing media" until applicable horizontal standards developed with the advice of Task Force CEN 151 "Horizontal" are available.

Only products which do not contain peat and whose organic content is derived from the processing or re-use of waste (as defined in Council Directive 75/442/EEC on waste (1) and Annex I to that Directive) will be considered for the award of the eco-label.

The products must not contain sewage sludge. Sewage sludge (not sewage sludge) is only allowed if it meets the following criteria:

- ✓ Sludge from on-site effluent treatment in the preparation and processing of fruit, vegetables, cereals, edible oils, cocoa, coffee, tea and tobacco; canning production; yeast and yeast extract production, molasses preparation and fermentation;
- ✓ Sludge from on-site effluent treatment in sugar processing;
- ✓ Sludge from on-site effluent treatment in the dairy industry;
- ✓ Sludge from on-site effluent treatment in the bakery and confectionery industry;
- ✓ Sludge from on-site effluent treatment in the production of alcoholic and non-alcoholic beverages (except coffee, tea and cocoa).

The minerals must not have been extracted from:

- ✓ Sites of Community importance notified under Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora;
- ✓ Natura 2000 network sites, consisting of special areas of conservation for birds (SPAs) under Council Directive 79/409/EEC on the conservation of wild birds (4) and of areas designated under Directive 92/43/EEC, or equivalent, located outside the European Community, which are covered by the relevant provisions of the United Nations Convention on Biological Diversity;

In the organic components of the growing medium, the content of the following elements must be lower than the indicated values, measured in dry matter weight:

Elemento	mg/kg (en materia seca)
Zn	300
Cu	100
Ni	50
Cd	1
Pb	100
Hg	1
Cr	100
Mo (*)	2
Se (*)	1,5
As (*)	10
F (*)	200

(*) Sólo será preciso indicar la presencia de estos elementos cuando se trate de productos que contengan materias procedentes de un proceso industrial.

Required product information

The following information, printed on the packaging or on a description sheet, must be provided with the product:

- ✓ Name and address of the person responsible for marketing;
- ✓ A descriptor that identifies the type of product;
- ✓ Batch identification number;
- ✓ Quantity (in weight or volume);
- ✓ The main components (with a proportion of more than 5% by volume) involved in the manufacture of the product.

Where appropriate, the following information on the use of the product must be provided with the product, printed on the packaging or on a description sheet:

- ✓ Recommendations on storage and expiry date of use;
- ✓ Safety guidelines on the handling and use of the product;
- ✓ Description of the purpose for which the product is intended and any restrictions on its use;
- ✓ An indication of the suitability of the product for certain plant species (e.g. calcareous or calcicultural);
- ✓ pH and carbon/nitrogen ratio (C/N);
- ✓ An indication of the stability of organic materials ("stable" or "very stable") according to a national or international standard;
- ✓ A statement on the recommended instructions for use.

Procedure for the development and revision of EU ecolabel criteria-

This procedure is regulated by Regulation EC No 66/2010 of the European Parliament and of the Council of 25 November 2009

Preliminary report.

The preliminary report must contain the following elements:

- ✓ Quantitative indication of the potential environmental benefits related to the product group, including consideration of the benefits from other similar European and national or regional EN ISO 14024 type I ecolabelling schemes,
- ✓ Reasoning for choice and scope of product group,
- ✓ Consideration of any possible trade issues,
- ✓ Analysis of other environmental labels' criteria,
- ✓ Current laws and ongoing legislative initiatives related to the product group sector;

- ✓ Analysis of the possibilities of substitution of hazardous substances by safer substances, as such or via the use of alternative materials or designs, wherever technically feasible, in particular with regard to substances of very high concern as referred to in Article 57 of Regulation (EC) No 1907/2006;
- ✓ Intra-community market data for the sector, including volumes and turnover,
- ✓ Current and future potential for market penetration of the products bearing the EU Ecolabel;
- ✓ Extent and overall relevance of the environmental impacts associated with the product group, based on new or existing life cycle assessment studies. Other scientific evidence may also be used. Critical and controversial issues shall be reported in detail and evaluated;
- ✓ References of data and information collected and used for issuing the report.

Proposal for draft criteria and associated technical report

Following the publication of the preliminary report, a proposal for draft criteria and a technical report in support of the proposal shall be established.

The draft criteria shall comply with the following requirements:

- ✓ They shall be based on the best products available on the Community market in terms of environmental performance throughout the life cycle, and they shall correspond indicatively to the best 10-20 % of the products available on the Community market in terms of environmental performance at the moment of their adoption;
- ✓ In order to allow for the necessary flexibility, the exact percentage shall be defined on a case-by-case basis and in each case with the aim of promoting the most environmentally friendly products and ensuring that consumers are provided with sufficient choice;
- ✓ They shall take into consideration the net environmental balance between the environmental benefits and burdens, including health and safety aspects; where appropriate, social, and ethical aspects shall be considered;
- ✓ They shall be based on the most significant environmental impacts of the product, be expressed as far as reasonably possible via technical key environmental performance indicators of the product, and be suitable for assessment according to the rules of this Regulation;
- ✓ They shall be based on sound data and information which are representative as far as possible of the entire Community market;
- ✓ They shall be based on life cycle data and quantitative environmental impacts, where applicable in compliance with the European Reference Life Cycle Data Systems (ELCD);
- ✓ They shall take into consideration the views of all interested parties involved in the consultation process;
- ✓ They shall guarantee harmonization with existing legislation applicable to the product group when considering definitions, test methods and technical and administrative documentation;
- ✓ They shall consider relevant Community policies and work done on other related product groups;

- ✓ The proposal for draft criteria shall be written in a way that is easily accessible to those wishing to use them. It shall provide justification for each criterion and explain the environmental benefits related to each criterion. It shall highlight the criteria corresponding to the key environmental characteristics;
- ✓ The technical report shall include at least the following elements:
  - The scientific explanations of each requirement and criterion;
  - A quantitative indication of the overall environmental performance that the criteria are expected to achieve in;
  - Their totality, when compared to that of the average products on the market;
  - An estimation of the expected environmental/economic/social impacts of the criteria as a whole;
  - The relevant test methods for assessment of the different criteria,
  - An estimation of testing costs;

Final report and draft criteria

The final report shall contain the following elements:

- ✓ A one-page summary of the level of support for the draft criteria by the competent bodies;
- ✓ A summary list of all documents circulated in the course of the criteria development work, together with an indication of the date of circulation of each document and to whom each document has been circulated, and a copy of the documents in question;
- ✓ A list of the interested parties involved in the work or which have been consulted or have expressed an opinion, together with their contact information;
- ✓ An executive summary;
- ✓ Three key environmental characteristics for the product group;
- ✓ A proposal for a marketing and communication strategy for the product group;
- ✓ Any observations received on the final report shall be taken into consideration, and information on the follow-up to the comments shall be provided on request.

Manual for potential users of the EU Ecolabel and competent bodies

A manual shall be established in order to assist potential users of the EU Ecolabel and competent bodies in assessing the compliance of products with the criteria.

Manual for authorities awarding public contracts

A manual providing guidance for the use of EU Ecolabel criteria to authorities awarding public contracts shall be established.

The Commission will provide templates translated into all official Community languages for the manual for potential users and competent bodies and for the manual for authorities awarding public contracts.

COST BENEFIT ANALYSIS (SPAIN MODEL)

Adopted methodology

The economic analysis defined for the RE-LIVE WASTE, as illustrated in the project Application Form, activity 3.6 “Economic evaluation of the pilot activities”, is designed to a variety of different stakeholders. These include both the private sector (companies) and the public sector (public institutions and governments).

The former are the implementers of the application of the development technology tested by our project, the latter instead plays a role of authorization and support, also financial, in the diffusion of these plants and their products both at national and international level.

Therefore, considering the different interests of the two subjects, it is necessary to direct the choice of the economic dissemination tools to be produced, towards a typology that highlights the main information required at the enterprise level and at the government level, such as to allow them to make a choice, supported by objective data.

For this reason, it was defined, already in the drafting phase of the project, to carry out both the Cost Benefit Analysis (CBA), mainly aimed at the public sector, and the Business Plan (BP), for which companies have a greater interest. In fact, even for projects subsidized by the European Union, the CBA is a fundamental piece of information in the decision-making process.

CBA is an analytical tool for judging the economic advantages or disadvantages of an investment decision by assessing its costs and benefits in order to assess the welfare change attributable to it.

CBA is the most functional toll for public assessment: it permits to appraise the project’s contribution to welfare based on the collective cost/benefit assessment of an investment choice. Usually, Standard CBA is structured in seven steps:

Description of the context:

- Presentation of the socio-economic, institutional, and political context

Definition of objectives:

- Needs assessment
- Projects relevance

Identification of the project:

- Project activities
- Body responsible for project implementation
- Definition of the impact area

Technical feasibility & Environmental sustainability:

- Demand analysis (current and future)
- Option analysis
- Environmental considerations, including EIA and climate change
- Technical design, cost estimates and implementation schedule

Financial analysis

- Cash-flows for project costs and revenues, including residual value
- Sources of financing
- Financial profitability & Sustainability

Economic analysis:

- Fiscal corrections
- From market to shadow prices
- Evaluation of non-market impacts
- Economic profitability

Risk assessment:

- Sensitivity analysis
- Qualitative risk analysis
- Probabilistic risk analysis

Many of the data used for the BP are common with those of the CBA financial analysis, however the data aggregation must be appropriately reformulated and some items must be deleted or recalculated.

The evaluation of the convenience of the project with respect to other alternatives, including the hypothesis "zero" (no intervention on the present system), is based on the calculation of the net value resulting of revenues (sales of fertilizer) minus production costs minus opportunity costs. This last cost, during a normal operating year, results of the actual cost of slurry treatment by farmers without having carried out the investment. The **payback period (years)** and the **internal rate of return** (IRR) are calculated in the financial analysis.

At the base of the economic analysis is the key concept of the use of shadow prices to reflect the social opportunity cost of goods and services. One of the critical points to pay close attention to it, if necessary, is therefore the transformation of the prices observed on the market, which can be distorted in shadow prices. Furthermore, appropriate tax corrections must be made because taxes and subsidies do not constitute real economic costs or benefits for society. Finally, it is required to carry out a correct evaluation of non-market impacts and do a correction for externalities.

In order to standardize the CBA foreseen in the deliverable 3.6.1 of our project with the one currently used in the evaluation of projects by the European Union we have followed the “**Guide to**

Cost-Benefit Analysis of Investment Projects – Economic appraisal tool for Cohesion Policy 2014-2020" published in 2014 and available in this link:

https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

Definition of Objectives

This Plan leads to the optimization of waste management so that the net cost of treatment is minimal and even allows the resulting product to be put on the market. This can be in the form of a solid fertilizer and/or in the form of an effluent with a low nitrogen and phosphorous content, which can be used for fertigation.

Thus, we will improve the innovation capacities of the actors involved in the management of the by-products of intensive livestock farming. Our approach will define a value proposition and the steps needed to achieve it.

From **the farm point of view**, the following objectives can be proposed:

- The reduction of the amount of effluent to be dispose of; This objective will produce, as benefit, the reduction of soil pollution levels;
- The reuse or sale of struvite-based fertilizers. This target will reduce the disposal costs and unit production costs at farm level for milk and meat production.

From **the community point of view**, the objectives to be pursued can be, among others:

- The encouragement of the adoption of technologies and systems suitable for the production of struvite. This objective will produce the benefits, of reducing the soil pollution levels and the quantity of wastewater to be disposed of
- Favouring the association of the farms that propose the installation and operation of a plant for the production and sale of struvite. This objective will produce the benefits, of reducing the soil pollution levels and the quantity of wastewater to be disposed of; the second objective will increase the competitiveness of farms, the greater competitive capacity of farms along the supply chain productive,

Methodology

Specifically, two contrasting and complementary methodologies have been used to prepare this evaluation.

In our case, we will formulate a value proposal based on the combination of two innovation models. These are Design Thinking and the Lean Canvas model. The first one is oriented to the design of the plant (case of the RE-LIVE WASTE project on which this work is based), while the second one describes the value proposal, including testing and revision mechanisms. Design Thinking develops innovative solutions, incorporating people's concerns, interests and values into the design process, with five formulation stages: "empathize", "define", "devise", "prototype" and "test".

Design Thinking Process. Kelley and Littman (2001) and own elaboration

The last two phases correspond to pilot activities of the RE-LIVE WASTE project. The evaluation of the pilot actions has allowed us to identify the strengths of the tested solutions, in socio-economic and environmental terms.

The Lean Canvas corresponds to the "Idea" phase as it translates these ideas into a business model. An outline of Lean Canvas is as follows:

In summary, the stages we have followed are as follows:

- ✓ Problems and needs that our product can solve;
- ✓ Define the main characteristics that will solve the problem;
- ✓ Formulate a value proposal indicating what we offer to solve these problems;
- ✓ Express what makes our product special or different;

- ✓ Defining target customers;
- ✓ Identify the channels that will make our company known;
- ✓ Defining revenue streams;
- ✓ Analyze the main costs.

While the complementary tools that have been used to collect data for this economic assessment have been the following:

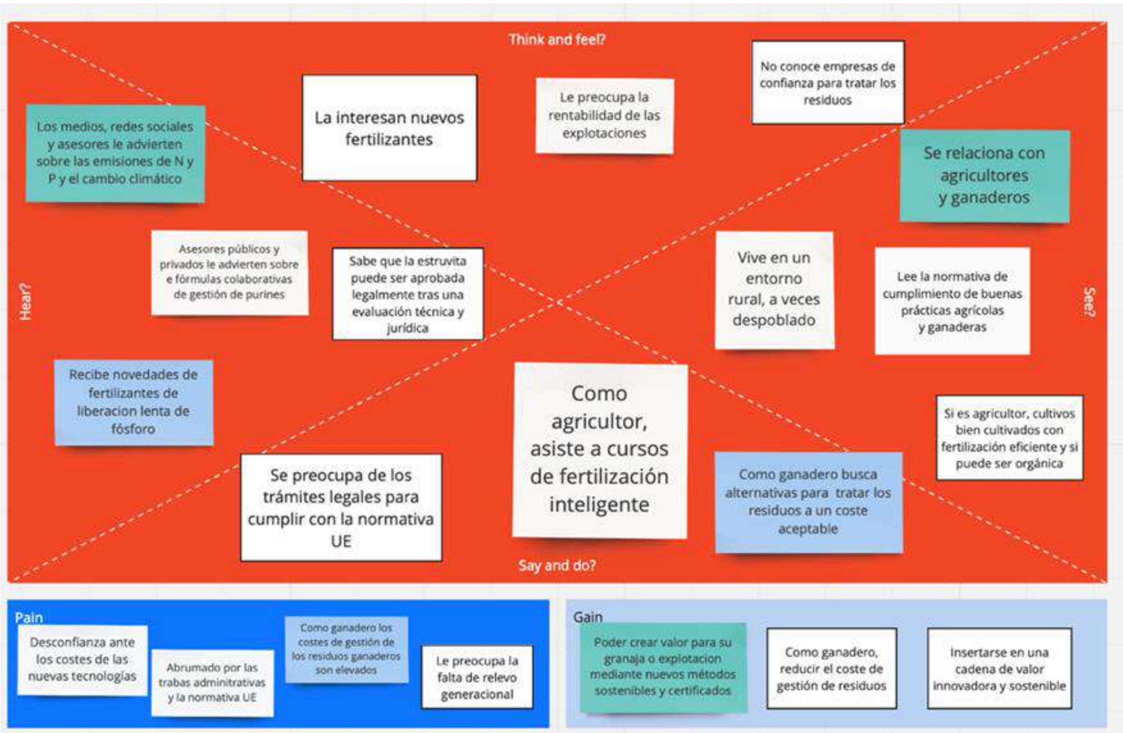
- ✓ Multi-actor workshops. They focus on analyzing internally the capacity for innovation in the agricultural system and the structural conditions provided by the agricultural innovation system. The workshop methodology is very useful for defining and analyzing prototypes. Participatory workshops identify, categorise and analyse constraints.
- ✓ Semi-structured individual interviews. They collect data from experts and validate secondary or workshop data. They serve as a guide for SWOT production. They collect what potential clients of the P recovery process can see, think, hear and do in the form of struvite, including farmers and ranchers with some capacity for innovation and environmental sensitivity. The SWOT assesses the weaknesses, threats, strengths and opportunities for obtaining struvite-based organic fertilizer.
- ✓ Secondary data, collected from official sources, policy reports, projects, legislation and project evaluations. In our case we use: a) data provided by scientific articles on phosphorus recovery technologies; b) technological data provided by the partners of the RE-LIVE WASTE project; c) livestock waste management manuals provided by public bodies; d) statistical data on market trends provided by the Ministry and Departments of Agriculture of the Autonomous Communities.
- ✓ Experimental data. They have been collected during the validation phase of the prototype, during the start-up and operation of the pilot plant.

Problems to be solved

Nutrient recovery is considered to reduce costs and comply with waste regulations. Given EU regulations on nutrient management and water quality (Common Agricultural Policy, Water Framework Directive, Nitrates Directive, etc.), tertiary treatment with enhanced P removal is already common practice for many municipal and industrial wastewater treatments (European Environment Agency, 2013).

We are interested in knowing the need for a new product based on phosphate salts precipitated from livestock waste. To do this we have used secondary data sources, but have also consulted experts from the RE-LIVE WASTE project. The project network has been designed to ensure connections between actors in the quadruple helix (research, business, public sector and civil society). The consortium is made up of 10 full and 3 associated partners, with complementary competences and well-defined roles to guarantee successful project execution. The partnership has been designed to ensure transnational cooperation and connections between actors of the quadruple helix and involves HEIs and research bodies (NRD-UNISS, CUT, FAFS UNSA), public authorities (Laore, MOA), 2 specialized companies (SERECO), a regional agency (SERDA), 4 livestock SMEs (ALIA, Armenis Nicos, Cooperativa Produttori Arborea, PD Butmir), 2 CSO (FGN and LAUNIO).

The main problems identified during the application of the methodology described for this economic assessment are related to slurry management. Farmers do not always have facilities to store large volumes of manure and have to apply it when the nutrient leaching potential is higher (e.g. in rainy conditions). But nutrients are also highly mobile in suspension compared to a crystallized form of struvite, which increases the risk of contamination. Acceptance of new fertilizers depends on evidence of their agronomic benefits compared to traditional fertilizers (Antille et al., 2013). According to the experts consulted, new materials should preferably be available in a physical form that allows their homogeneous distribution in the field using conventional application equipment.



Empathy map, drawn from surveys and interviews

In conclusion, the problem to be solved affects not only one but several potential users, in particular livestock and farmers, but also public administrations.

- ✓ As economically available mineral phosphate reserves begin to decline, technology must provide alternative sources of phosphate to make it possible to do without this mineral;

- ✓ High levels of phosphorus applied to the land that exceed the needs of the crop increase the potential for phosphorus to leach into the water. Fields that receive animal waste often have a high level of P in soil test samples;
- ✓ Transport costs to move excess nutrients to other areas of lower livestock density may be excessive.

Project identification

The RE-LIVE WASTE project has contemplated the implementation of a pilot plant that allows the reduction of nitrogen levels and the recovery of phosphorus in the form of a precipitate that, when crystallized, leads to the obtaining of an organic fertilizer enriched with struvite. The composition of pig slurry is favorable for the recovery of P due to its high content, 3-4 kg of P_2O_5 per ton, (Schoumans et al., 2017) and because this phosphorus is mainly present in inorganic form.

The pilot project has been launched at the facilities of the Centre for Animal Research and Technology (CITA in Segorbe, Castellón), taking advantage of an existing infrastructure for the treatment of slurry to which innovative technology has been applied.

The possibility of converting the by-product into a commercial product motivates us to explore the precipitation of struvite (hydrated phosphate of phosphorus and ammonium) by controlled addition of magnesium chloride, a process that has been used and improved (FERTINNOWA, 2018). This process has been tested to treat effluents from anaerobic digesters, as well as pig and poultry droppings. The recovery of phosphorus can reduce the dependence of the rock on phosphate as a raw material (Huygens et al., 2019). This proposal explores the possibilities of struvite marketed as a fertilizer directly "as is", after conditioning (e.g. granulation, drying), or as a raw material (ingredient) for the production of fertilizers or blends.

Part of the acquisition of information has been possible thanks to ALIA (partner of RE-LIVE WASTE) that participated in the LIFE Metabioresor project (project that validated a pilot plant that managed waste and by-products from the pig sector). To prepare this economic evaluation, the partners collected all the available information on the state of the art, the cases where fertilizers have been produced from waste, the studies carried out on the economic valorization of the digestate, etc. The net revenues and costs of the obtention of the recovery of phosphorus in terms of fertilizer can be compared with the actual costs of treatment of the pig slurry by farmers in the selected region.

For the best identification of the project, we need to consider two basic aspects:

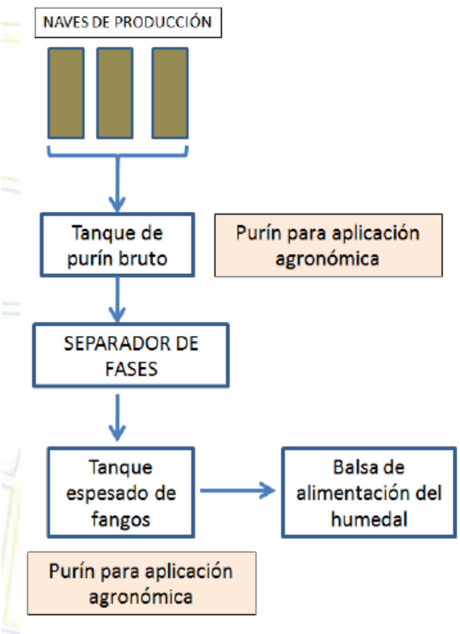
The first one of them is the logistic. The plant has to be located where the effluent supply is constant.

The second one is the assessment of the comparative advantage of struvite compared to the chemical fertilizer from an agronomic point of view and the abatement of the pollutant point of view. In a future project's deliverable, we will have the agronomic validation, in order to accomplish this aspect.

In this case, the positive assessment of both the above-mentioned precondition has been crucial in the validation of the investment project.

Project activities

The RE-LIVE WASTE project works with a livestock cooperative in the region of Murcia, (ALIA). In this province there is a census of more than 1.7 million pigs, according to the MAPAMA livestock surveys. The RE-LIVE WASTE project adopts a technology applicable to pig farms for fattening. The cooperative is located in a municipality that, according to the last Agricultural Census, gathers more than 40% of the cattle farms in the region (almost 300 farms, with a production of more than 3 million m^3 of slurry per year, according to the project's experts).



Several comprehensive slurry treatment projects are being implemented in the region through a combination of phase separation, aeration-decantation ponds and artificial wetland filtration. The farm in question raises pigs for fattening with an average number of piglets produced per year of 15,375. Of these, 2,800 are fattened up to an average weight of 80 kg. There are also some breeding sows for small production in a closed cycle. The daily production of pig manure is around 40 m^3.

Subsequent treatment of effluents for struvite crystallization Source: Faz Cano (2015)

The company has recently installed a centrifugal separator that has a working capacity of 5-10 m^3/h and a solid capture rate of over 75%. The liquid fraction obtained, which still has a high content of ammonium nitrogen ($N\text{-}NH_4$), approximately 1,700 mg/l, will be subjected to the experimental de-ammonification process with the production of struvite, as part of an integral treatment.

The farm already has a comprehensive management scheme in which the separation of solid-liquid phases can be followed by sludge thickening and a wetland filtering treatment. This is an additional management strategy.

On this case we will build the business model that is explored in the next chapter, including the precipitation of phosphate salts as part of a subsequent treatment of the effluent.

In order to avoid interference from organic matter and to obtain a product composed mainly of the desired precipitates, the system must also be combined with methods that deal with the elimination of organic matter, such as anaerobic digestion, which is not the case for the influent treated in our study.

The project has tested a technology that allows for a design (i) applicable to different types of organic waste; (ii) feasible on a relatively small scale; (iii) that recovers N and P simultaneously; (iv) that can be combined with various alternative pre-treatments, with or without anaerobic digestion (which allows for the generation of electricity, but requires a scale of production with higher capital costs).

In collaboration with the Generalitat Valenciana and the Fundación Global Nature, La Unió de Llauradors set up a pilot plant in Segorbe (Castellón) for approximately 6 months, where it treats the slurry to obtain the struvite precipitate needed to carry out agronomic trials and market studies. The company also collaborated actively in the dissemination of the technology and its results to groups of farmers, livestock owners, businessmen and public administrations. The Regional Ministry of Agriculture, Rural Development, Climate Emergency and Ecological Transition was asked to provide a space where the pilot project could be implemented by making improvements to the existing plant at the IVIA's facilities in Segorbe. The construction and operation of the pilot plant was paid for within the approved project and its cost corresponds to the plant with a maximum capacity of 20 m^3 of slurry per day. Our economic analysis corresponds to a larger scale plant that can process up to 50 m^3 per day.

The intention of La Unió, the promoter of the experimental plant, has been to try out different types of slurry to try and find more solutions and possibilities, including digestate from the Murcian farm as well as the slurry produced by CITA itself, and other organic by-products from commercial farms that have also undergone the same treatment process.

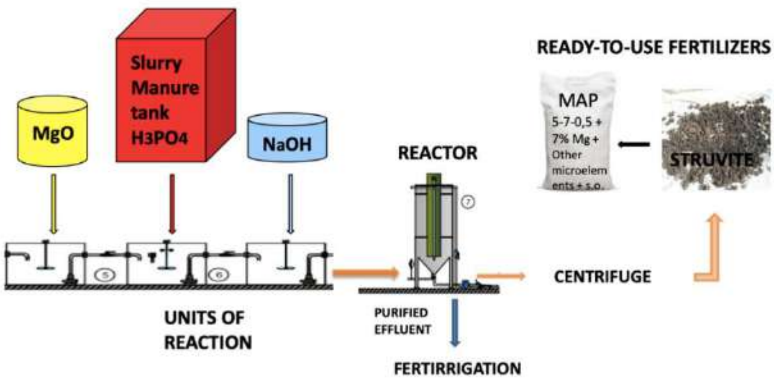
Small livestock production units (closed-cycle pigs, poultry, rabbits, etc.) already exist at the research center to carry out experimental and research activities. There is also an experimental plant for the treatment and purification of pig farm slurry consisting of storage tanks and wastewater separation systems with press and centrifuge filters. The experimental plant for the production of organic struvite was inserted in the above-mentioned plant and uses some devices that were already in operation or have been functionally restored within the framework of the RE-LIVE WASTE project.

The project consisted in the execution of experimental tests to obtain O-SEP (Organic Struvite Enriched Precipitate) from various types of initial influences. Thus, a cycle of tests was carried out with the pig manure produced by the farms present in the experimental center, while another cycle of tests was carried out with the centrifuged pig slurry obtained using an innovative centrifugal separator installed in the Murcian company referred to above. The pre-treated slurry was transported with appropriate tankers authorized for the transport of waste water and stored at the Segorbe test facilities in special tanks of 1 m^3 capacity to allow its storage and use in biosafety conditions. To be viable, the process must be valid using several alternatives of organic influences, so that it can put into value different by-products from the area.

Our technological process is oriented, among other aspects, to

- ✓ Introduce into the market a slow-release fertilizer that can contribute to the elimination of groundwater pollution and to saving over time, nutrients (N and P) according to the biological requirements of the crops;
- ✓ To remove ammonia, both from raw zootechnical wastewater and from anaerobic wastewater (digestate), by reducing the ammonia concentration in the wastewater to values compatible with biological nitro-desnitro processes;
- ✓ Comply with EU legislation limiting nitrogen emissions to the atmosphere (particularly ammonia and nitrogen oxides) as the main cause of acid rain;
- ✓ Contribute significantly to the containment of bad odors by reducing the diffusion of ammonia, hydrogen sulfide and volatile acids;
- ✓ Overcome the restriction on land availability, in accordance with the "Nitrate" directive;
- ✓ To be able to reuse slurry treatment plants already in use, with the appropriate structural changes. It is desirable to reuse dismantled facilities (tanks, reservoirs, pumps, etc.) that are already present in an obsolete plant;
- ✓ To be able to design small-medium scale adaptable systems that can be adapted to cooperatives or individual farm associations.

Struvite production is one of the known technologies for recovering nutrients from animal manure and digestate.



Source: RE-LIVE WASTE Project

Despite the differences between the substrates to obtain struvite, the chemical reaction is a precipitation reaction that takes place under alkaline conditions, when the concentration of Mg^{2+}, NH_4^+ and PO_4^{3-} exceeds the solubility of the product, according to the following reaction:

$$Mg^{2+} + NH_4^+ + H^nPO4^{n-3} + 6H2O \rightarrow MgNH_4PO_4 * 6H2O + nH^+$$

According to the study by Huygens et al. (2019), the agronomic efficiency of precipitated phosphate salts is similar to that of fertilizers obtained from mining and synthetics. In trials of cereal crops fertilized with struvite, in the initial stage, a reduction in the number of grain spikes is observed due to short-term P deficiency, but it is counteracted by the capacity of the crop's root system to absorb P in the various stages of plant growth, compensating its lower rate of P dissolution in relation to water-soluble P fertilizers (Talboys et al., 2016).

The production of struvite is proposed from the recovery of chemical elements from manure and slurry with a high concentration of suspended solids, and can be adapted to different geographical specifications and pre-treatments (mechanical separation of solid-liquid phases, anaerobic digestion, etc.). The technology must be suitable for individual farms or for collective waste management.

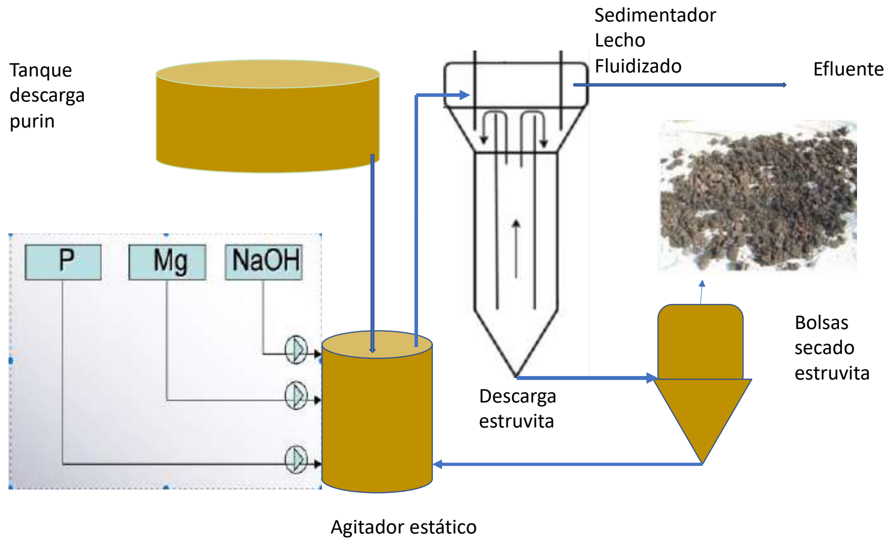
The specific process has so far not been tested under real conditions in Europe. Here the technology has an important role, and based on the accumulated experience, the project has contemplated to test, in the pilot experience, the Sermap® technology, a technology used is quite simple to be managed by a rural community in the different European regions.

The name Sermap® is derived from the combination of the company name Sereco Biotest (technology partner of the RE-LIVE WASTE project) and the acronym MAP (ammonium magnesium phosphate). The process is described in detail in the work of Poletti et al (2012).

Initial experiments with this process indicated that by properly regulating the ratio of ammonium ion concentrations in wastewater to the added magnesium and phosphate ions it is possible to obtain a reduction of ammonium ion of more than 79%. Struvite precipitation depends on two main factors: the molar ratio of $Mg:NH_4:P$ and the pH value of the wastewater. For pig wastewater, the Mg content is relatively low, so it must be added in the right amount to precipitate struvite crystals. Magnesium oxide (MgO) is often used as a source of Mg due to its fast-dissociative nature. As regards the required pH, aeration is a method that increases the pH of reactive wastewater by removing CO_2. In the experimental phase, the results obtained proved to be satisfactory for the reduction of ammonium in the liquid phase, for the economic management of the process, for the reproduction of the tests and for the physical-chemical and agronomic properties of the precipitate obtained.

The values supplied in an ammonia sensor for the wastewater at the inlet (NH4 inlet) and after SERMAP® treatment (NH_4 outlet) and the corresponding reductions were measured. In all cases NH_4 concentration values below 500 mg/l were achieved. The percentage reductions were between 39.9% and 79.2%, sometimes without any solid-liquid pre-treatment. Thus, an effluent from the MAP treatment was obtained with an NH4 content between 200 and 460 ppm (average 346 ppm) and average COD always in the range between 1,100 and 1,400 ppm. These values allow the complete elimination of nitrogen by sending the effluent to a standard biological treatment. The process can be modulated to graduate the nutrient reduction desired based on the initial concentration of nitrogen in the slurry, the daily volume to be treated, the amount of fertilizer to be produced, the availability of agricultural areas for fertigation and the prices of the reagents used.

Source: Own elaboration from Poletti et al (2012)



Possibleinstitutions/companies responsible for implementation

The type of institutions/companies that can benefit from this technology and start up a plant for the processing and evaluation of slurry have been defined in 3 groups, two of them private and the third as public administration.

- ✓ *Farmers, livestock breeders and their associations* (cooperatives, livestock integrators...), especially those working with organic and sustainable production systems. This group includes not only food producers, but also gardeners, landscapers, turf growers, ornamental crop companies and, to a lesser extent, centers that carry out agronomic research.
- ✓ *Companies involved in the biofertilization industry* that might be interested in completing their range of products for sale or including struvite precipitate in the mixture.
- ✓ *Public institutions* whose area of operation includes a high density of manure-producing farms and do not yet have a solution in place. In this case, local or regional public institutions should be considered, never with a very large territory as the logistics and transport costs would make the project unviable.

In any case, the EU's Nitrates Directive and concerns about nitrogen and phosphorus emissions to soil and water open a trade window from a circular approach. Although the market could be developed internally in rural areas, the fertilizer produced could also be exported outside the producing region.

The big beneficiaries of the technology are the farmers by reducing the management costs of environmental compliance. The sector is aware of the need to minimize phosphorus inputs into surface waters.

Consequently, if anything can encourage the search for nutrient reduction or recovery strategies, it is both the evolution of the census (probably affected by a delocalization of production from Northern Europe) and the process of restructuring pig farms itself. The cost of innovative processes makes them more applicable by larger farms or co-operatives that must act responsibly with regard to waste disposal.

Technical feasibility and environmental sustainability

Analysis of the demand

The main demands detected are related to the primary sector, both the sources of elements for the fertilizers and the better management of the slurry in the livestock farms are current and necessary demands that have to be solved in a short term:

Increased demand for nutrients for agricultural production

The agricultural sector uses large amounts of N and P fertilizers each year. There is a consensus among experts that the use of P fertilizers depends on population growth, changes in diets, and GDP growth.

According to Springmann et al. (2018), the world population is expected to grow from 6.9 billion in 2010 to 10 billion in 2050 and to multiply GDP by a factor of between 2.6 and 4.2. There will still be a demand for fertilizers. However, the consumption of mineral fertilisers in the EU-28, which according to Eurostat reached 1.3 million tons of P in 2017, is likely to grow slowly over the next decade.

The stabilization of apparent consumption of P-mineral fertilizers in Europe is largely due to changes in the Common Agricultural Policy (CAP) since 2003. The most relevant has been the decoupling of direct payments and their link to the fulfilment of conditions related to environmental quality, food safety and animal welfare.

Replacement of phosphorus sources

Phosphorus application levels are already above the globally acceptable thresholds. According to this article, ambitious phosphorus management-recovery technology and improved efficiency in nitrogen and phosphorus fertilization will be able to reduce the impacts of fertilizer application on soil and water.

On the other hand, it is estimated that more than one million tons of rock phosphate are extracted annually (Kool et al., 2012). Nitrogen-based fertilizers are mainly produced from ammonia through the energy-demanding Haber-Bosch process. Any method that allows the recovery of nutrients to be recycled as fertilizers is of great interest in reducing energy consumption, Greenhouse Gas (GHG) emissions and the depletion of natural resources.

According to a report by the Joint Research Centre on technical proposals for new fertilizer materials under the revision of the Fertilizer Products Regulation (Huygens et al. 2019), the opening of the fertilizer market to struvite and other biogenic waste materials will contribute to the replacement of extracted rock phosphate and processed P fertilizers.

A significant use of materials recovered from municipal wastewater, sludge and manure is expected by 2030. As well as a reduction in fertilizer use of at least 20% while ensuring and improving soil fertility (Green Deal-the farm to fork strategy)

Potential of organic farming

The organic farming model offers potential for struvite. The production of struvite from organic raw materials is in line with the objectives, criteria and principles of organic farming and the circular economy. The EU Expert Group for Technical Advice on Organic Production (EGTOP) has positively evaluated some dossiers proposing the authorization of recycled P products as fertilizer under the EU Organic Agriculture Regulation (889/2008). The EGTOP concluded that struvite recovery reduces N and P losses in surface water, recycles nutrients and reduces consumption of non-renewable P resources, so struvite should be authorized for organic farming provided that the production method ensures hygiene and safety of contaminants.

Today, manure and compost are the main source of P in organic farming. According to Eurostat, in 2017, the percentage of total agricultural area used within the EU for organic farming was 7%. In the last 5 years the agricultural area under organic system increased by 25% in the EU. Thus, the organic farming sector could become an important market in the near future. The CAP recognizes the role of organic farming and, in fact, under the first pillar of the CAP, organic farms benefit from the green direct payment without any additional obligations because of their significant overall contribution to environmental objectives.

Within the strategy approved by the European Commission in 2020, an increase in the area of organic farming to 25% is planned (Green Deal-the farm to fork strategy)

Farmers' needs

The advantages of recovering nitrogen and phosphorus are multiple: some farmers can reduce fertilizer costs; others have limitations on spreading manure and slurry under certain conditions, periods, quantities or locations, and at the same time have limited storage facilities; all face strict regulations in the EU. Finally, animal production can gain added value in the eyes of consumers with good practices that reduce soil and water pollution. In order to undertake proper management of slurry, farmers must adapt to the limitations of regulations that can be transformed into opportunities.

Directive 91/676/EEC on nitrates makes it possible to maintain water quality in the European Union by preventing the pollution of surface water and groundwater.

The farmer must make decisions on how to manage the waste according to the local context. Manure is defined as a Category 2 animal by-product in accordance with Regulation (EC) No 1069/2009. Most European countries have similar regulations regarding (i) licenses required to house animals, (ii) storage of manure and slurry to allow better agronomic use and (iii) prohibited periods for the extension of the area (generally the winter months). A common concern is water pollution by nitrates, but also ammonia emissions and odors.

In areas with a high density of livestock, with a surplus of nutrients, the transformation of slurry into forms that facilitate its transport and valorization is proposed.

Tests carried out

After installation of the plant, final inspection and acceptance tests, and after ensuring that the electrical and hydraulic connections are installed according to the project specifications, the experimental plant was ready for the first tests in January 2020. The RE-LIVE WASTE project held a training workshop in mid-January, coordinated by SERECO, where the advantages of the project and how to deal with the O-SEP precipitation process were discussed. The local RE-LIVE WASTE project team supervises the process by operating directly in the test plant or by collecting data in strict cooperation with the remote-control station. The technical staff of SERECO, the project's technological partner, has been at the disposal of the local staff also through direct interventions on site if necessary. The information transmitted to the control station allows for feedback on the operation of the plant by modifying specific experimental conditions (e.g. with regard to reagent dosage, flow rates, loads, liquor retention time and so on).

Average chemical composition of the influent of the pilot plant in Segorbe (Castellón)

Parameter	Raw Slurry	Pre-treated Slurry
Ph (upH)	7.2	7.7
E.C. (dS/m)	22.5	17.5
S.T.S. solids in suspension (g/l)	20	12
M.S. dry matter (g/l)	150	6
T.S. total solids (g/l)	20	12
BOD5 (g/l)	15	4
COD (g/l)	87	50
Organic Nitrogen (NTK) (g/l)	2.6	2
Ammonium Nitrogen (N-NH4+) (g/l)	2	1.7
P Total (mg/l)	0.3	0.1

Ca (mg/l)	280	120
Mg (mg/l)	290	195
K (mg/l)	1,800	1,750
Na (mg/l)	1,250	1,200
NO3- (mg/l)	320	165

Source: data provided by ALIA and La Unió

Taking this into account the composition data of the influent, the RE-LIVE WASTE project formulated the assumptions for the test trials with a nitrogen reduction attempt in the order of 35-75%. As a starting point, the production of O-SEP was assumed to be in the order of 36-64 kg SEP per kg NH_4 reduced. Assuming a daily treatment of a 3 m^3 batch, the expected amount of dry SEP obtained can reasonably vary between 81 kg and 173 kg depending on the achievable rate of NH_4 reduction. It is estimated that the average daily cost for reagent consumption should be between 29 and 64 euros per 3 m^3 batch. All these data mentioned above should be considered merely as starting assumptions and can only be confirmed after enough tests.

In February 2020, initial analyses were carried out to determine the efficiency of nutrient reduction and the characteristics of the solid fertilizer obtained. The analyses are being carried out preferably in a local laboratory, under the supervision of the Global Nature Foundation. The result of the experiments takes into account the chemical characteristics of both the liquid and the solid phase, i.e. respectively the input material that will be environmentally improved (e.g. the effluent may be of interest for fertigation according to the provisions of the Nitrates Directive) and O-SEP may be considered a valuable fertilizer. The key parameters of the liquid phase to be highlighted and thoroughly verified will be Total N; ammonium; nitrates; nitrites; total P; orthophosphates; magnesium; calcium; potassium. The key parameters of the solid phase to be highlighted and thoroughly checked will be Total N; Total P; Calcium; Crystallographic analysis (% struvite)

The first tests consisted of carrying out the reaction in the corresponding tank and separating the treated suspension (with a significant moisture content, 98.5%) by centrifugation between the liquid and solid phases. The treated suspension samples were subjected to a centrifugation process to separate the two phases that make up the product. Once separated, the supernatant is removed (the upper part of the slightly yellowish-brown liquid product), leaving the lower part where the remains of the black organic matter are deposited. Once the results of the samples and the corresponding supernatant have been obtained, the effectiveness of the N and P reduction process can be checked. The percentage of nutrients removed would in theory be the part of the organic matter deposited at the bottom after the centrifugation process.

Pilot plant

Samples obtained

Note:

- ✓ **A1**: sample of pre-treated slurry from a livestock company without polyelectrolytes;
- ✓ **A2**: sample of pre-treated slurry from a livestock company with polyelectrolytes;
- ✓ **MIX**: mixed sample of pre-treated slurry and CITA slurry;
- ✓ **CITA**: sample of slurry produced at CITA's facilities;

Component	A1	A2	MIX	QUOTE
Total N (%)	3.3	2.5	3.2	3.3
P (%)	12.6	8.1	13.6	13.3
Mg (%)	16.3	8.8	17.8	16.9
Total organic matter (%)	31.9	53.3	28.6	29.6
Organic carbon (%)	14.2	23.8	12.8	13.2
pH at 19ºC (%)	7.2	7.4	7.2	7.2

It must be taken into account that in the tests carried out the levels of the elements are in very low percentages as a result of the humidity of the product, and the errors are higher than if it were a product with a lower amount of humidity.

The agronomic tests being carried out by the SERECO technology partners and the University of Sassari will make it possible to evaluate future actions to improve the environmental and economic efficiency of the materials obtained.

The process is effective in reducing the level of NH4 by up to 40%. The high content of organic carbon and total organic matter allows the precipitate obtained to be considered as organic.

Financial Analysis

As explained in the introduction to the Economic Evaluation, this CBA is based on the experience and data obtained from the pilot plant in Spain. Even so, a financial analysis template is attached to this economic evaluation so that the project partners or any potential investor can have a first idea of the viability of the project to be implemented.

This financial template includes the initial data for the first 3 years (in case a staggered investment or expansion of production is required during the first years). By filling in only the data specific to each situation and territory (blank cells) the tool automatically calculates the total costs and income, cash flow, IRR and Payback of the project.

Another principle that characterizes this financial analysis is the principle of Prudence. All the theoretical or empirical parameters used have been defined with the utmost caution, i.e. in the case of value ranges, those most unfavorable to the project's profitability have been taken into account. The intention is to have a scenario that is as realistic and improvable as possible.

For the development of this financial analysis, the income and expenses of an industrial production plant have been taken into account, as well as the previous costs (existing installations before the plant was finished) and all this regulated by the cash flow which is the parameter that has given us the final financial projection. The initial conditions of the industrial plant developed are as follows:

- ✓ Daily treated slurry: 50 m^3/day
- ✓ Plant operating days: 300 days/year
- ✓ Fertilizer performance: 17 kg / m^3 slurry
- ✓ Level of NH_4 reduction: < 40%

In the specific case of Spain, it has been considered that all the investment is made from the first year and therefore from this year the plant is productive at its maximum performance

Revenue / Sales

This section considers the sales of the two products generated by the plant: the fertilizer enriched with struvite and the liquid effluent enriched with nutrients (water with fertilizer).

The principle of prudence and all possible references have been followed in setting sales prices. The explanation for each of the products is as follows.

- ✓ Fertilizer enriched with struvite: currently (due to the legislation in force) there is still no real market for fertilizer enriched with struvite, so the price estimate must be theoretical and prudent. Furthermore, the price obtained in the struvite business model will depend on the degree of purity in this precipitate in the solid fertilizer obtained. The work of Li et al (2019)[4] contemplates prices between 300 and 800 USD/Tn. Westerman et al (2010)[5] considers 330 USD/Tn. The experts and partners of the SERECO project propose a valuation between 200 and 400 €/Tn. In our case, a price per ton of fertilizer of 300 €/Tn has been projected, which, in addition, is in line with the prices of fertilizers of similar characterization but without the struvite precipitate.
- ✓ Enriched liquid effluent. This effluent is suitable for agricultural irrigation, both blanket and drip. In addition, this irrigation water contains nutrients and microelements useful for agricultural development (K, Mg, B, etc.). A selling price of 0.10 €/ m^3 has been contemplated. This price is lower than that paid in most irrigation communities for water without any type of incorporated nutrients.

On the one hand, no account has been taken of the income that will be produced by charging for the transport of the products generated to the end customer. Similarly, transport costs have not been considered for this purpose. It is a pure expense without a profit margin, so it is neither counted as income nor as an expense.

Production. YEAR 1			
Product	Units	€/unit	Subtotal (€)
Struvite (Kg)	255,000	0.30	76,500
Liquid effluent (m^3)	10,500	0.1	1,050
		TOTAL	**77,550**

[4] Li, B., Udugama, I. A., Mansouri, S. S., Yu, W., Baroutian, S., Gernaey, K. V., & Young, B. R. (2019). An exploration of barriers for commercializing phosphorus recovery technologies. *Journal of Cleaner Production*, *229* 1342-1354.

[5] Westerman, P. W., Bowers, K. E., & Zering, K. D. (2010). Phosphorus recovery from covered digester effluent with a continuous-flow struvite crystallizer. *Applied engineering in agriculture*, *26*(1), 153-161.

On the other hand, a small income has been considered, which we will now detail:

- ✓ Subsidy from the local entity where the plant is located to solve the problem of slurry management in their municipality. After speaking with several mayors and regional deputies, they have confirmed that such a plant, due to its high environmental and social commitment, could easily get subsidies from the local and regional entities present in the area where the plant operates. The cautious figure of 5,000 €/year has been calculated
- ✓ I charge farmers for the management of their slurry. Currently the farmer is paying around 4 €/ m^3, either to a certified company that takes it away or it is the cost that he needs to bury or treat those slurries in compliance with current regulations. In this case we have considered as income a charge of only half (2 €/m^3) and in the section of "opportunity cost" and following the principle of prudence we have considered that the current cost of the management of the farmer's slurry is 3 €/m^3.

Other revenue. YEAR 1	
Description	€/year
Grant from local authority	5,000
Management service to farmer	30,000
TOTAL	**35,000**

All of this gives us a total annual income of approximately 106 K €

Investment

In order to calculate the investment, the facilities to be built must be taken into account and if already built facilities are being used (in the case of Spain) they must also be valued and calculated as investment costs.

On the other hand, they have been considered:

- ✓ Building license. Tax required to carry out any work. It is usually 3% of the investment budget although here we have considered 5% for possible contingencies.
- ✓ Building project. The construction of this plant is quite simple and involves, above all, connecting different tanks and attaching some valve and pump to move the effluent being treated. Even so, the signature of a registered professional is needed to avoid future problems. This signed project has been quantified at 2,500 € (market price in Spain);
- ✓ Assembly of the plant. In addition to the purchase of the necessary materials and accessories, a company with expertise in hydraulic connections is needed to assemble the entire plant and operate it properly. The real cost in Spain of this work was around 10,000 € although to avoid unforeseen events in the financial analysis we have considered an assembly cost of 15,000 €;

Facilities cost. YEAR 1			
Description	€/unit	nº units	Subtotal
Structural works	10,305	1	10,305
Electrical instalation	4,500	1	4,500
Pipes	1,477	5	7,384
Valves	4,259	2	8,517
Agitator	500	2	1,000
Submersible pump	2,500	2	5,000
Mohno pump	2,150	3	6,450
Dosing station	8,200	1	8,200
External connections	2,800	3	8,400
Tank A	12,000	1	12,000
Settler B	18,000	1	18,000
Tank C	12,500	1	12,500
Aditional structures	5,000	1	5,000
Sensors	8,500	1	8,500
Collection trolley	850	1	850
		TOTAL	**116,607 €**

Previous Facilities cost. YEAR 1			
Description	€/unit	nº units	Subtotal
Tank for subirrigation	4,000	3	12,000
Storage tank	22,000	1	22,000
Dry System	8,000	1	8,000
Existing rook and platfrom	4,000	1	4,000
Homogeneization tank	3,800	1	3,800
		TOTAL	**49.800 €**

Taxes and project	
Description	€
Building License	8,625
Building project	2,500
Plant Assembly	15,000
TOTAL	**26,125 €**

Residual value

The residual value, in the field of accounting, refers to the price or value that a fixed asset has when its useful life is over. In other words, once the depreciation and amortization charges applicable to an intangible asset have been deducted, what remains is the residual value.

In summary, this value could be said to refer to the amount of money the company expects to receive for this asset once its useful life is over. For example, if a computer is purchased for a certain price, after a certain number of years its useful life for the company will end. After this use, the company expects to be able to sell or give it away for a price. This price would be the residual value of the computer.

To be able to calculate the residual value, several considerations or assumptions must be considered.

- This value can only be applied to fixed assets. In other words, those assets which the company acquires, and which are used in its core business on a lasting basis. These assets could therefore be buildings, machinery, or transport tools;
- It is calculated on the initial value of the product either purchased or manufactured;
- Based on this value, depreciation and amortization charges are applied each year. Once the useful life of the good itself has ended, it is not necessary to deduct these costs.

In our case, we will apply a residual value of 30% over 10 years. We have estimated this 30% based on the average useful life of the fixed installations (10 years), the annual maintenance (10%) and the two extraordinary maintenances at 4 and 8 years of the less durable machinery (50%).

To calculate the profitability of the project and the financial projection (IRR) this value is subtracted from the amortization.

Residual Value	
Facilities	€
Permanent fac.	109,205
Resid. rate value	30%
TOTAL	**32,761 €**

Extra maintenance

Besides the ordinary maintenance (10% of the investment) foreseen in the production costs, an extra maintenance is also foreseen.

This extra maintenance fulfils the following premises:

- It is calculated on the acquisition value of the mechanical and mobile installations (pumps, pipes, dispensers...). Precisely with those that have not been included to calculate the residual value;
- It is carried out in years 4 and 8 which is when it is calculated that there can be important depreciations in this machinery;

- Each year 50% of the value of its cost is charged. With this practice we ensure that by year 10 we will be able to have a plant that has been amortized, in full operation and with all the facilities still functional for several more years.

Extra Maintenance	
Facilities	€
Machinery	63,302
Resid. rate value	50%
TOTAL	**31,651 €**

Loan Valuation

In the case of the cost of the loan we have used the following assumptions:

- The entire investment cost is considered to be borrowed (including possible pre-installations). Principle of prudence.
- An average interest rate of a mortgage loan in the country where the plant is to be built is incorporated.
- In Spain, a fixed mortgage interest rate of 2.75 % has been considered. It is a little higher than the official rate, but we cover possible subsequent increases.
- For an investment of approximately €200,000 the interest payable is slightly more than €30,000.

Production costs

In the production costs, we have considered all costs other than investment, necessary personnel, and fixed external services. In other words, production costs are the variable costs that are related to the amount of slurry treated per year. The detail is as it follows:

- ✓ Transport. The number of trips required to supply the slurry plant and for the plant to deliver its products to the final customers has been calculated:
  - From the farm to the plant. In this case it will be the farmers who will take their slurry to the plant, deposit it there and take away their certificate of approval as having managed their slurry correctly. All the farms have tank trucks (we have considered an average volume of 20 m^3/ tank). Therefore, the transport to the plant is not an expense for the plant but for the farmer, it is the same transport cost they are currently having to bury or manage these slurries. It is intended that they take

advantage of the trip and once the slurry is emptied, they can take the liquid effluent enriched in nutrients and the struvite enriched fertilizer from the plant;

- From the plant to the customer. In this case the products to be sent to customers outside the plant (those who are not farmers who are suppliers of slurry) will be a cost of the plant which will be passed on in the selling price of the product. As explained in the section on "income", this increase in the price of transport has not been considered, just as the increase in expenditure for the same concept is now not taken into account. They counterbalance each other.

Transport. YEAR 1			
Concept	Trips/year	€/trip	Subtotal
From Farm to Plant	*750*	*0*	0
From Plant to Client	*64*	*0*	0
		TOTAL	**0**

✓ Reactive. In this case, the average of the reagents used in all the tests carried out in the Spanish plant (8 different tests) and the real cost of acquiring these reagents have been considered. This cost can be seen to be very reduced for larger quantities and by exploring other suppliers where the reagent used in our plant is a by-product of their activity. This point is further developed in the "Market Identification" point of this Economic Evaluation. In summary the quantities required, and average prices used for this financial analysis have been as follows.

- Phosphoric acid (73%) H_2PO_4. Average dose: 1 liter/m^3. Price: 0.88 €/liter. Density: 1.58 Kg/liter
- Magnesium oxide (50%). MgO. Average dose: 12 Kg/m^3. Price: 0.085 €/kg
- Caustic Soda (30%). NaOH. Average dose: 0.4 kg/m^3. Price: 0.50 €/liter. Density: 1,33 Kg/liter
- There are also 4 packs of 100 blotter bags in each pack. A consumption of slightly more than 250 bags has been calculated for one year, 400 of them are foreseen.

Reagents. YEAR 1			
Name	kg	€/kg	Subtotal (euros)
Phosphoric acid 73%	*18,360*	*0,88*	16,156
Magnesium oxide 50%.	*180.000*	*0,085*	15.300
Sodium Hydroxide 30%	*5,999*	*0,5*	2,999
Filters bags	*750*	*4*	*3,000*
		TOTAL	**37,456 €**

- ✓ Energy. Empirically it has been bought that the consumption of the process is 120 Kw/h, considering the current prices this means almost 14,000 € per year
- ✓ Insurance. The obligatory insurance of civil responsibility and the voluntary insurance of accidents at work are considered. Between the two, it costs approximately 2,000 € per year.
- ✓ Renting of the plot. As it is an agricultural plot and needs less than 5,000 $m^{2,}$ a rental cost of 300 € per month has been estimated
- ✓ Facilities maintenance. It has been calculated, following the principle of prudence, at 10% per year of the total investment

Other P. Costs. YEAR 1	
Name	Cost/year (euros)
Energy	13,797
Insurances	2,000
Renting	3,600
Maintenance	14,077
TOTAL	**33,473 €**

Note: We have not considered indirect taxes (VAT). The purchase of the raw materials and the investment of the installations involve input VAT, but the sales of the final products involve output VAT. The only item that does not involve VAT is staff costs, so we will always have more VAT charged than borne (it improves our cash flow). The regulation of this tax is done every 3 months, so it has been considered more explanatory not to include it in the financial projection.

Personnel costs

This section has considered the staff needed to maintain this size of plant throughout the year. After the pilot experience we have detected that only 1 qualified operator can manage all the slurry programmed for these dimensions (50 m^3/day).

Even so, and following the principle of prudence, we have over dimensioned this section as follows:

- ✓ Manager. Person trained for the chemical control of the resulting products, supervision of the process and commercial relationship with customers and suppliers. It is considered that with a 20% of their time is more than enough.
- ✓ Technical. An operator qualified in the management of the plant and its processes can perfectly assume all the production foreseen, even so we have considered 1.5 technicians, attending to the obligatory rest periods and possible contingencies that may occur.

Staff cost. YEAR 1				
Position	€/month	% time	No. of months	Subtotal (€)
Manager	3,500	20%	12	8,400
Technician	2,000	100%	12	24,000
Technician	2,000	50%	12	12,000
				0
			TOTAL	**44,400**

On the other hand, professional expenses for external services have been considered. These would be fixed costs regardless of the volume of production. Details of these expenses are summarized in:

- Analysis of the products obtained. Every week (50 a year) an analysis is made of each of the products obtained, the fertilizer and the enriched water. It is considered an expense of 40 € for each product every week.
- Accounting. It has been considered an external cost of a professional company in tax and labor consultancy of 200 € per month
- Marketing. Due to the local and nearby nature of the plant, the marketing costs should not be too much, even so it has been quantified a cost of 2,500 € per year to maintain the brand, the website, the social networks and to be able to make some small investment in local communication projects.

External Assistance. YEAR 1	
Service	Cost/year (€)
Labs /Analysis	4,000
Accounting	2,400
Marketing	2,500
TOTAL	**8,900**

Opportunity costs

The quantification of this cost is complicated and depends on many factors. In this case we have defined it through surveys and interviews with farmers who manage their own slurry and by reviewing the invoices of other farmers who hire approved companies to manage their slurry. The average cost is more than 4 euros/m^3.

Although the average opportunity cost is 4 €/m^3, we have assumed that the competition for offering this service will be greater in the medium term, so the services offered may be cheaper than the current ones.

To calculate the opportunity cost to be used we have used a 0.75-conversion factor, related to the new competitors that will emerge to offer the slurry management service. Therefore, the cost used is 3 €/m^3.

Moreover, as this is a positive cost (which is subtracted from the rest of the costs) its lower quantification still makes our financial projection more prudent.

It is important to note that this cost positively affects the profitability of the plant. It is a cost that is already being incurred and therefore when starting up the plant it must be considered in the Cost Benefit Analysis

CURRENT Direct Costs. YEAR 1			
Position	m^3	€/m^3	Subtotal (€)
Pig Slurry	15,000	3.0	45,000
			0
		TOTAL	**45,000**

Profitability. Financial Projection

Considering all the revenues, expenses and variables listed and explained in this financial analysis we obtain an economically interesting financial projection although not as a big business. Its main potentialities are its low environmental impact (as previously developed) and its high social impact (maintaining population in rural areas and with a tendency to depopulation).

Table: Cost-Benefit Analysis. Summary in euros/year

Year	Revenues	Investment	Production Costs	Staff Cost	Opportunity Cost	Net cash flow	Accumulate net cash flow	Payback
1	112,550	192,227	73,494	53,300	45,000	-166,757	-166,757	-166,757
2	112,550		73,494	53,300	45,000	25,936	-140,821	-140,821
3	112,550		73,494	53,300	45,000	26,416	-114,405	-114,405
4	113,676	31,651	74,229	54,366	45,450	-4,968	-119,373	-119,373
5	114,812		74,971	55,453	45,905	26,950	-92,423	-92,423
6	115,960		75,721	56,562	46,364	27,219	-65,204	-65,204
7	117,120		76,478	57,694	46,827	27,488	-37,716	-37,716
8	118,291	31,651	77,243	58,848	47,295	-3,893	-41,610	-41,610
9	119,474		78,015	60,024	47,768	28,028	-13,582	-13,582
10	120,669		78,795	61,225	48,246	144,906	131,324	131,324

IRR	**9,8%**
PAYBACK (years)	**14,64**

Economic conclusions

Under the assumption that the markets for goods and services used by the investment project are competitive and adding the revenues to the opportunity cost, as the lack of expenses related to the wastewater management service (indirect effect), we can consider the monetary evaluations presented in the previous table proper of the economic analysis. In this perspective, if the market interest rates were lower than the internal rate of return, it will be possible to calculate the positive advantage deriving from the investment project to the community, even before taking into account the externalities (positive and negative) and the tax adjustment.

A Return on Rate Investment (IRR) about 10% is not quite attractive for pure investors, (risk capital o angel investors) but it does make the project a very interesting initiative to solve the problem of slurry in areas of high livestock density. As demonstrated during this Financial and Economic Evaluation, it is the cooperation between public administrations (local and regional) together with private initiative (farmers and stockbreeders) that can make the implementation of this technology possible in certain production and rural areas.

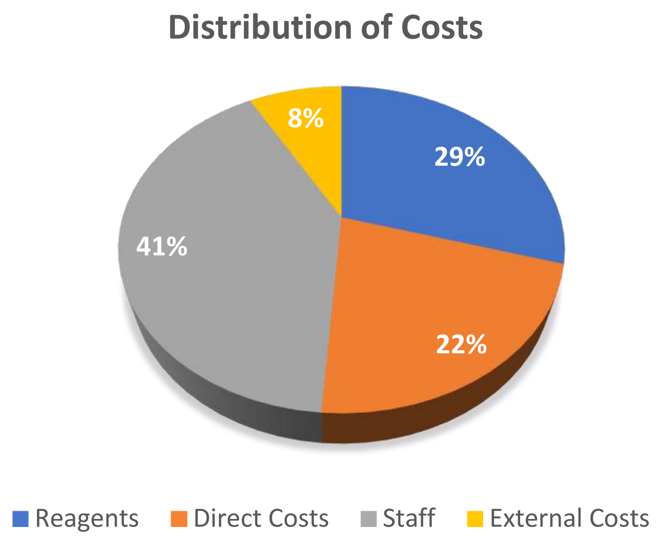
The not excessive initial investment required, the simplicity of the technology and the urgent need to achieve sustainable solutions for the management of livestock by-products make RE-LIVE WASTE a reference to be taken into account, both by public and private actors, when implementing community or cooperative initiatives for the sustainable management (economic, social and environmental) of livestock by-products.

The sales price of the products (struvite-enriched precipitate and mineral-enriched effluent) has been very conservative during this analysis. Quite low values were chosen, but when the technology is adjusted to each substrate and the struvite precipitate can be further enriched, the selling price could increase, and this has a very direct impact on viability. Example: if instead of 275 Euros/Tn (0.275 €/Kg) we could sell it at 0.350 €/Kg the IRR would be 20% and the Payback less than 3 years.

For the investment it has been considered the construction of a plant from zero, without any previous structure. In all the farms there are already rafts, tanks and pipes that can be used perfectly. If we had not taken into account the facilities already built in the case of the plant studied, the profitability would have been very similar to that described in the previous example.

The cost of reagents accounts for 30% of the total production costs of the plant (including personnel). As explained above, these reagent costs can be greatly reduced by exploring other industries (salt mines, mining, canning...) where the waste generated would serve as reagents for our technology.

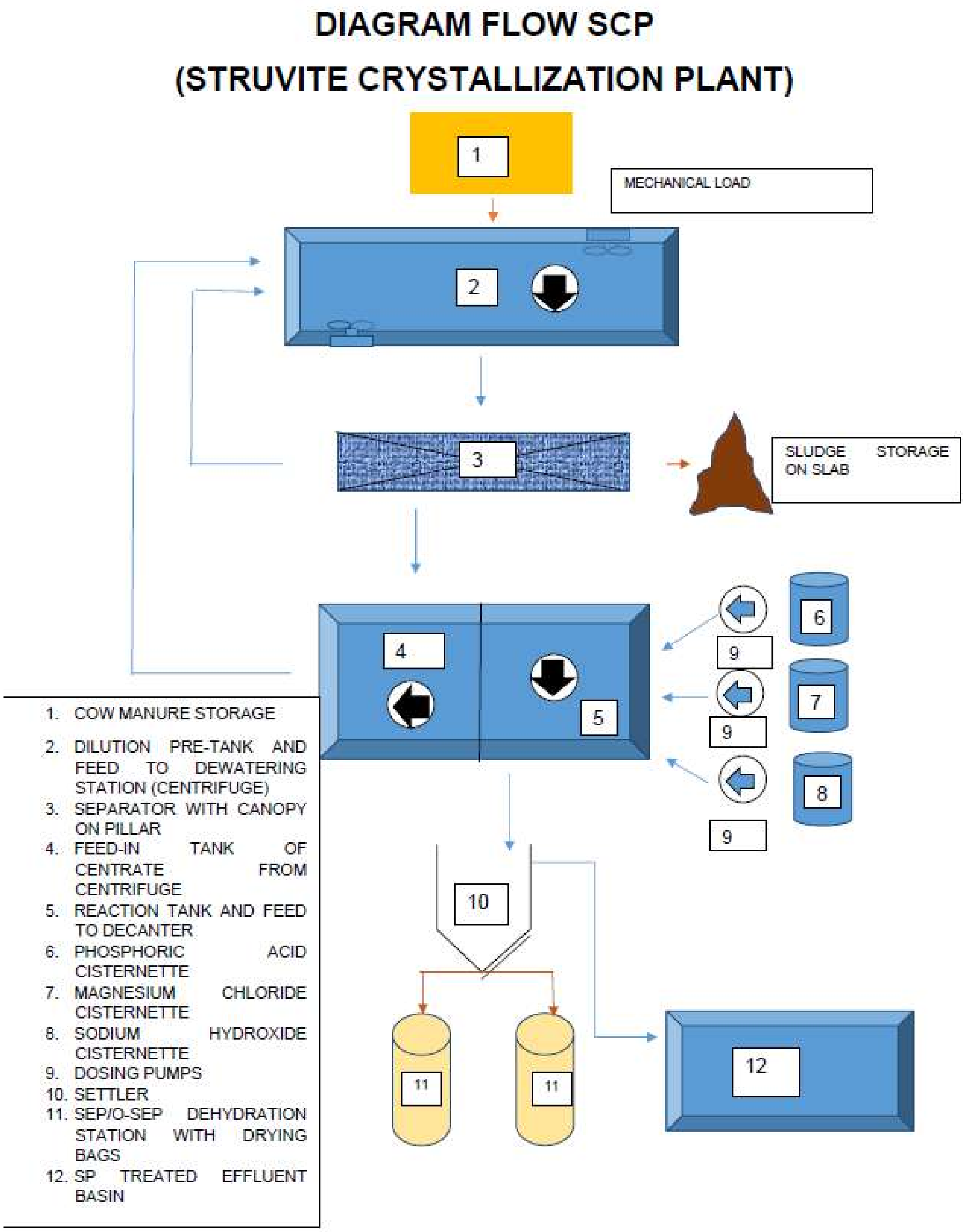
Personnel costs represent the highest cost of production of all (< 40%). As explained in its section, this is an oversized cost. This means that at least 25% more than projected could be produced without increasing personnel costs. This has an important impact on profitability: the IRR would be close to 15 euros and the Payback would be less than 4 years.



About opportunity costs, a current cost of 3 €/m^3 of slurry managed has been considered. The calculations of the farmers who manage it themselves and the invoices of the farmers who hire approved managers place us at around 4 €/m^3. If we had used this value, we would have obtained an IRR of 17.5% and a Payback of a little more than 3 years. In this point it is important to emphasize that the current normative limitations are increasing this cost of management in a fast and uncontrolled way, so it is a factor to be taken into account that also plays in favor of this technology.

COST BENEFIT ANALYSIS (Bosnia -Herzegovina)

Process strategy



Below is a functional description of the process units with an indication of some performance characteristics of the electromechanical units:

Functional organization of the plant

The pilot plant is made according to the following major treatment units:

- Cow manure pre-treatment (solid-liquid separation)
- Treatment system of the liquid centrate for its deammonification and subsequent recovery as STR/O-SEP

The process units are as following:

- Dilution, homogenization and loading into the separator (centrifuge);
- Solid-liquid separation
- Storage of the solid fraction (sludge)
- Storage of the liquid centrate and back-feeding for dilution
- SP pre-treatment (stripping), SP reaction and loading into the settler
- Sedimentation/precipitation of STRU/O-SEP
- Dehydration by means of draining bags.

Dilution unit, homogenization and loading of the separation system

The process begins in a pre-fabricated reinforced concrete tank with a rectangular plan having a geometric capacity of 66 m^3. The loading of the manure in the tank takes place with a mechanical device that can be a mechanical shovel connected to a tractor or another vehicle already used in the company for moving manure.

The volume of mixing tank is 36 m^3 of manure / day, i.e. to perform a mechanical loading from storage every 2/3 days and by considering a dilution so to obtain a matrix with below 10% of TS.

The tank is equipped with two submerged mixers with a nominal power of 11 kW each one exhibiting a mixing power equivalent to an axial thrust between 2,000 and 2,500 N.

Given the characteristics of the manure to be treated, encompassing the presence of straw and vegetable material, the loading is carried out through a chopper pump with a capacity compatible with the operational capacity load of the separator. It is estimated a daily operational capacity of the centrifuge of 4-5 h which corresponds to a transfer rate of 4- 5m^3 / h. The estimated power of the pump engine is 7.5 kW.

Units for the storage of solid and liquid fractions

The separation unit consists in an helicoidal compression separator, suitable for treating manure up to 20% of s.s., having the following characteristics:

- Steel screw conveyor;
- 0.74 mm stainless steel filter;
- Variable and adjustable working capacity up to 45 m^3 / h;
- Rated engine power of 4 kW.

Separator is completed by an overflow pipe hydraulically connected to the loading/ homogenization tank and a pipe for the discharge of the centrate to the storage tank used also as a back-load tank for dilution purposes.

Liquid storage after separation

The storage tank for liquid part is placed off-ground on a dedicated concrete slab, is provided with a partition wall and have a geometric volume of 65 m^3. 55 m^3 volume is used for storage and dilution re-load of the centrate to the loading tank. The remaining 10 m^3 is an Struvite production reaction compartment connected to the previous one by means of a weir.

Pre-treatment and reaction SP unit for the production of struvite and O-SEP

The centrate loading tank is separated in two compartments (storage and reaction compartment) by a partition wall. The second volume is functionally arranged to allow the pre-treatment of the centrate and the subsequent formation of STRU/O-SEP. The pre-treatment consists in a CO_2/NH_3 stripping operated through stirring by means of a bubble diffuser plate placed at the bottom of the tank, connected to a compressor mounted outside the tank.

The batch loading of the settler will be assured by a submerged transfer pump having an estimated power of 1.6 kW and a maximum flow rate of 5 m^3 / h.

Sedimentation unit and organic struvite recovery

This unit consists in a truncated cone-shaped sedimentation tank, with a cylinder at the top of it having a width of 1.8 m and a height of 2.2 m with a total geometric volume equal to 5.6 m^3. The reaction slurry (centrate) is loaded at the settler top. The lower conical section of the settler has a height of 1.4 m and a geometric volume of 3 m^3. The overall geometric volume of the settler is therefore 8.6 m^3.

The treated effluent is discharged by gravity, through a pipe, into a small tank of 10 cubic meters of geometric volume. The effluent reach by gravity the wastewater accumulation basin already present in the farm.

Sep dehydration system

The system for the dehydration of the precipitate consists of a series of draining bags in non-woven polypropylene with an overall capacity of 85 l. The placement of the draining bag and its removal from the bottom of the settler are done manually.

Reagent dosage unit

The reagents necessary for the struvite production reaction is stored in small tanks (cisternette).

The canisters are placed in separate room in container.

The reagents that are used in the process are:
- Phosphoric acid (H_3PO_4), 75% degree of purity;
- Magnesium chloride ($MgCl_2$) from 51% degree of purity;
- Sodium hydroxide (NaOH), 50% degree of purity.

All the above reagents are provided in a liquid formulation.

A metering pump provided with manual flow adjustment and indication of the flow rate on an analogical silk-screened scale is connected to each cistern.

<u>Sensors</u>

For purpose of monitoring the struvite production process, pilot plant is equipped with following sensors:
1. pH sensors (2X) installed in the tank connected to the settler for loading and in the SP-treated effluent storage tank
2. Ammonium sensors (2X) in the loading tank to the settler and in the effluent storage tank.

Local Comments

Production and drying of the precipitate is done at a same place, in pilot plant on location of PD Butmir. Produced biofertilizer will be placed in storage of PD Butmir, and based on supply demands of customer, biofertilizer will be delivered to market. Also, possibility is that PD Butmir use bio fertilizer in their own production of crops.

PD Butmir will make contract with selected suppliers for selling the bio fertilizer to a market. Targeted market would be shops which sell equipment and material for agriculture. In this case, PD Butmir will need to provide standard quality of bio fertilizer, as well the quantities. For these reasons, PD Butmir will need to regularly conduct analysis of produced bio fertilizer.

Financial Analysis

For development of this financial analyses, the income and expenses of industrial production plant have been considered and with cash flow which is giving us the financial projection of feasibility of production of STRUVITE in Bosnia and Herzegovina, at location of PD Butmir.

As plant is designed for treatment of:

- Daily treated manure: 30 m^3/day
- Plant operating days: 300 days/year
- Daily treated precipitate: 6 m^3/day
- Yield of fertilizer: 6 kg/ m^3 of precipitate;
- Level of NH_4 reduction ~ 40%.

In specific situation of PD Butmir, where there was not any kind of treatment of manure, all cost starts with establishment of the pilot plant. There was no previously invested financial means.

Revenue / Sales

Revenues are calculated on basis of production of 6 kg/m^3 of precipitate. Having in mind, that capacity of settler is 6 m^3 it is expected that for one year there will be produced and created income:

Production. YEAR 1			
Product	Kg	€/kg	Subtotal
Struvite	10,800.00	0.275	2,970.00
		TOTAL	2,970.00

Price of produced STRUVITE is based on prices of fertilizer with similar composition in Bosnia and Herzegovina.

Here is important to mention that PD Butmir doesn`t have any treatment of manure on their farm. Manure is transported directly on field or is storage in inadequate space. Because of this, wastewater from manure leaking uncontrolled polluting the soil and underground water. Because of this, PD Butmir paying water fee. Water fee is 6.775,26 € per year.

As a sub product in process of producing the bio fertilizer is dry manure (manure with 20-24% dry material) and liquid part of manure. PD Butmir have option to produce of dry manure pellets which is also possible to use for fertilizing the soil, especially in greenhouses or on small garden surfaces. It is estimated that this additional product from process would create revenue on yearly base:

Others Revenue. YEAR 1	
Description	€/year
Dry manure	126,000
TOTAL	126,000

Liquid part manure can be used for irrigation of the crops. For this action PD Butmir will need to purchase transfer tank (up 20 m^3) for transport of liquid part to field.

Investment

Investment for establishment and operating of the pilot plant, there was several expenditures. These expenditures were:

-creating main design of the pilot plant (spatial planning of pilot plant)
-construction of mixing tank and tang for storage and reaction tank;
- procurement of equipment
-services of the experts during the operating of the pilot plant.

Investment is shown in next tables:

Facilities cost. YEAR 1			
Description	€/unit	nº units	Subtotal
Creation of main desing of pilot plant	2,450	1	2,450
Construction of the mixing tank	6,000	1	6,000
Construction of the panel for container	3,000	1	3,000
Construction of the storage and reaction tank	8,500	1	8,500
Construction of collection tank	4,000	1	4,000
Mixer	10,585	2	21,170
Pump	6,420	1	6,420
Separator	25,681	1	25,681
Pump	3,532	1	3,532
Dosage units	5,410	3	16,229
Sensors	2,934	8	23,469

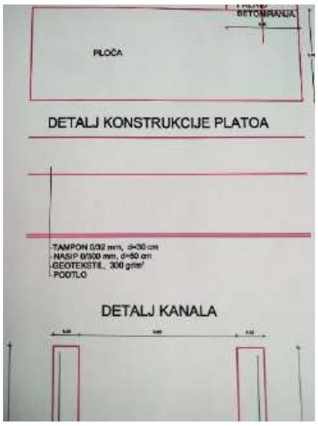
Compressor with diffusors	7,476	1	7,476
		TOTAL	127,927

Facilities cost. YEAR 2			
Description	€/unit	nº units	Subtotal
Settler	20,546	1	20,546
O-SEP station	35,343	1	35,343
Costruction for pump	3,061	1	3,061
		TOTAL	58,950

Facilities cost. YEAR 3			
Description	€/unit	nº units	Subtotal
Dryer for manure	25,000	1	25,000
Dry manure pelleting machine	35,000	1	35,000
		TOTAL	60.000

1. Creating main design of the pilot plant (spatial planning of pilot plant)

For purpose of spatial layout of the pilot plan of location of PD Butmir, it was necessary to create main design of pilot plant. Within main design was made spatial layout of the pilot plant but also the specification for mixing tank, storage tank and reaction tank. Specification of the tanks was base for procurement procedure for construction of the tanks which conduct by PD Butmir.



2. Construction of mixing tank and tang for storage and reaction tank

For purpose of installation of equipment for production of bio fertilizer, it was necessary to be constructed mixing, storage and reaction tank and tank for water which is left over from the process. Since this construction of tanks was not panned within the project, PD Butmir paid for construction of tanks.

3. Procurement of equipment

Investment in equipment in first phase was 120.000 €. Within this budget was procured necessary mixers, pumps, separator and dosage units for reagents. Also, in second year of operating of pilot plant was procured equipment for 60.000 € which include settler and O-SEP bags as an upgrade of pilot plant.

Production costs

For operational work of the pilot plant and in accordance with State-of-the-art report for PD Butmir case, it was foreseen using of three kind of reagents:

- Phosphoric acid 75% purity
- Magnesium chloride 51% purity
- Sodium Hydroxide 50% purity.

During testing process, it shows that for achieving good quality of bio fertilizer, it was necessary to use 8L of phosphoric acid, 9L of magnesium chloride and about 30 L of Sodium Hydroxide. Taking this amount of reagents necessary for production of bio fertilizer, and that pilot plant will produce bio fertilizer 300 day per year, total amount of reagents and their cost per year is:

Reagents. YEAR 1			
Name	L	€/L	Subtotal
Phosporic acid 75%	2,400	1.00	2,400
Magnesium chloride 51%	2,700	2.00	5,400
Sodium Hydroxide 50%	9,000	0.90	8,100
		TOTAL	15,900

Cost of reagents is cost which together with equipment for pilot plant mostly effect on economic feasibility of production of bio fertilizer.

Beside this, cost of transport of manure from stables to mixing tank on annual base is:

Transport. YEAR 1			
Concept	Trips/year	€/trip	Subtotal
From stable to plant	*5,745*	*0.50*	2,873
		TOTAL	2,873

Cost of transport of manure from stable to mixing tank is cost which exists and today, just that manure is transporting to storage place on farm.

<u>*Electricity for pilot plant*</u>

Having in mind power of installed equipment, it is necessary to be take into account and cost of electricity as one of expenditure for work of pilot plant. It is estimated that on annual base, it is necessary about 24.000 kWh per year. With price 0,08 € cost of electricity will be:

Electricity for operating the plant YEAR 1			
Concept	kWh/year	€/kWh	Subtotal
Electricity for operating the plant	*24,000*	*0,08*	1,920
		TOTAL	1,920

Personnel costs

<u>*Services of the experts during the operating of the pilot plant.*</u>

Within the project was engaged experts as a Local technical team in accordance with Methodological Protocol. Engagement was covered technical team which was consisting of chemistry engineer, plumber and electrician. Their task was to monitor work of pilot plant and to provide necessary support to local partners during testing the equipment. Cost of Local technical team for 4 months was 5,950 €.

Staff cost. YEAR 1				
Position	Cost/month	% time	Nº months	Subtotal
Technician	800	1	8	6,400
Electrician/plumber	500	0.50	8	2,000
LT team	1,487	1	4	5,948
			TOTAL	14,348

Services of the experts after testing period the operating of the pilot plant.

For operational work and monitoring of the pilot plant it is estimated that 2 persons would be engaged. One person, technologist, who would be in charge for proper work of pilot plant, monitoring and process of producing the bio fertilizer, management of reagents, etc. This person would be in charge for work of pilot plant. This person would be hire full time. Estimated salary for this person is 800 € per month, gross. Second person who are necessary for work of pilot plant is electrician/plumber, who would be engaged on demand. Estimation is that this person would work part time (50%) on pilot plant. PD Butmir have these professions on the farm.

Staff cost. YEAR 2				
Position	Cost/month	% time	Nº months	Subtotal
Technician	800	1	12	9,600
Electrician/plumber	500	0	12	1,200
			TOTAL	10,800

External assistance after testing

It is estimated that PD Butmir will need constantly monitoring the process and result of process. This means that regularly analyses of the bio fertilizer will be done, o maintains the quality and standard of it. For this reason, it is foreseen cost of laboratory analyses per year of 2.400,00 €.

Opportunity costs

Since PD Butmir didn't have any kind of treatment of manure, before establishment of pilot plant, in sort time they would need to invest on this kind of equipment or they would hire company that will treat their manure and waste water from farm. It is estimated that this kind of service would cost PD Butmir about 2,50 € per m^3.

Also, it is important to mention that in close neighborhoods of PD Butmir is and Farm for breeding of chickens. Their estimated quantity of slurry per day is about 10 m^3 of waste. If PD Butmir provide them service of treatment of their chicken waste by price of 1,50 €, this would create income for farm 4.500,00 € per year.

This leads us to final calculations of opportunity costs on annual base:

CURRENT Direct Costs. YEAR 1			
Position	m3	€/m3	Subtotal
Manure from farm	9,000	2.50	22,500
Chicken slurry from neghbor farm	3,000	1.50	4,500
		TOTAL	27,000

Profitability. Financial Projection

Financial projection of previously projected revenues, expenditures and some costs which will be reduced or eliminated from farm, it brings us to conclusion that this doesn't represent business which will bring to farm big income, as it is show in table:

Year	Income	Investment	Production Costs	Staff Cost	Opportunity Cost	Cash-Flow	Acumulate Cash-Flow	Payback
0						-493.754		
1	128.970	127.927	25.193	16.748	27.000	-13.898	-13.898	-507.652
2	128.970	58.950	25.193	13.200	22.950	54.578	40.680	-453.074
3	128.970	60.000	25.193	13.200	27.000	57.578	98.257	-395.497
4	130.260	123.439	25.444	13.464	27.270	-4.817	93.440	-400.314
5	131.562		25.699	13.733	27.543	119.673	213.113	-280.641
6	132.878		25.956	14.008	27.818	120.732	333.845	-159.909
7	134.207		26.215	14.288	28.096	121.799	455.645	-38.109
8	135.549	123.439	26.478	14.574	28.377	-564	455.081	-38.673
9	136.904		26.742	14.865	28.661	123.958	579.039	85.284
10	138.273		27.010	15.163	28.948	125.049	704.087	210.333

TIR	5%

PAYBACK (years)	8

On the other side, having in mind location of the farm, situation of the manure treatment on farm before project and necessity that farm need solve problem of manure and waste waters, it is obvious that these kinds of pilot plant have great impact on environment protection. At the end, without proper treatment of manure and waste waters on farm, it would lead to losing of environment permit for farm and it`s closing. It has to be clearly that **investment in environment protection is not expenditures but investment for future.**

Economic conclusions

Establishment of this kind of plants can be analyses from several aspects. These aspects are. From increasing the economic activity in market sector, providing additional services on farm, opening new working places, and above all reducing the cattle breeding impact on environment. All these aspects at least for case of Bosna and Herzegovina are very much important.

Introducing new technologies for treatment of cattle waste, will have impact through payment of VAT, which will increase income for this territory. Also, this will open new possibilities for farmers in different areas in Bosnia and Herzegovina to start this kind of plants and to provide to other farmers service of treatment of cattle waste.

Basic indicators of return on investment are:

1. The payback time of the investment shows in how many years the initial investment is returned. The better the project is with the shorter the payback period. It is the simplest method that predicts the time value of money. In our case, payback period is 8 years, with parameters which are include in economic evaluation. This is quite long period looking from aspect of investors.
2. the present net value of the project considers the time value of money. Namely, after the initial investment, the project will generate other cash receipts and expenditures (additional investments, revenues, expenditures, etc.). In case of pilot plant in PD Butmir, starting investment is quite high. The cause of this is that PD Butmir didn`t have any system of waste treatment or separation of liquid and solid part of manure. By establishing new equipment, it opens new expenditures such as electricity for pilot plant, new staff that will work and maintain on pilot plant and procurement of reagents for further production of bio fertilizer. It is estimated that after 5 years value of pilot plant will about 30% of initial investment.

On other hand, return of investment in equipment for animal waste treatment is long, and it may be not interested in investors who are not in this sector. For this reason, big farms, which have need for this kind of equipment will be like points where other farmers will be able to transport and treat animal waste.

Nevertheless, Bosna and Herzegovina on its way to become member state of European Union need to face with problem of intensive cattle breeding and waste which generate in this process. Because of that this project have much bigger impact, then just economic. Process of treatment of animal waste in Bosna and Herzegovina need to be implemented and monitored with the aim of improvement and adjusting this process.

COST BENEFIT ANALYSIS (Cyprus)

Process strategy

Technical details of the process

The pilot plant in Cyprus (Figures 1-2) is located in the area of Monagroulli in Limassol and part of it was initially constructed during the LIFE LIVEWASTE project (LIFE12 ENV/CY/000544, 2013-2016). To meet the requirement of the RE-LIVE WASTE project, the struvite crystallization reactor (SCR) was upgraded for its size (from 50 L to 250 L), while a phosphoric acid pump was added.

The raw treated effluent either comprised of pig slurry or mixed influent (with a composition of 50% pig slurry, 25% cheese whey, 25% chicken manure and occasionally fruit organic waste and barley). The livestock waste was anaerobically treated (in a2-staged anaerobic digester-AD), while the digestate effluent was filtered through filter bags and ultra-filtration ceramic membranes (UF) prior to struvite precipitation.

Struvite was produced in a 250 L continuously stirred struvite crystallization reactor (See Figures 3-5). Every 250 L batch produced approximately 4.5 kg of struvite. The struvite purity obtained from the pilot-scale experiments ranged from 89.2% to 99.6% based on the applied conditions.

Figure 1: *CUT's pilot plant in Monagroulli Limassol, Cyprus.*

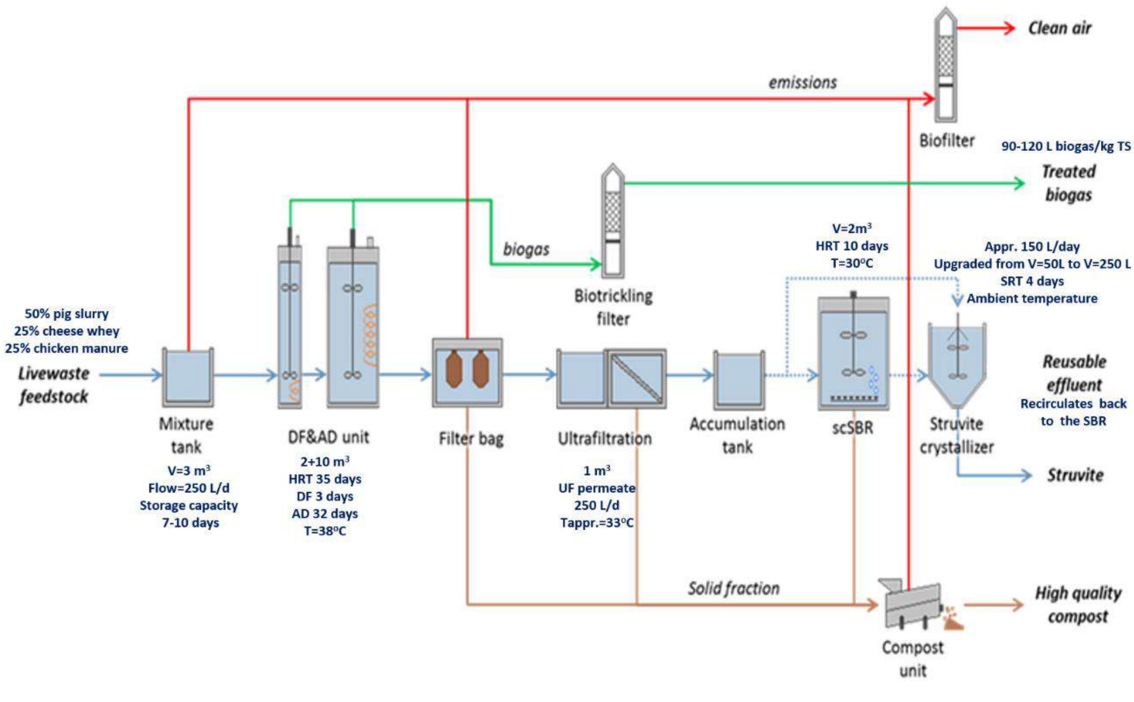


Figure 2: Treatment train of the CUT pilot in Monagroulli.

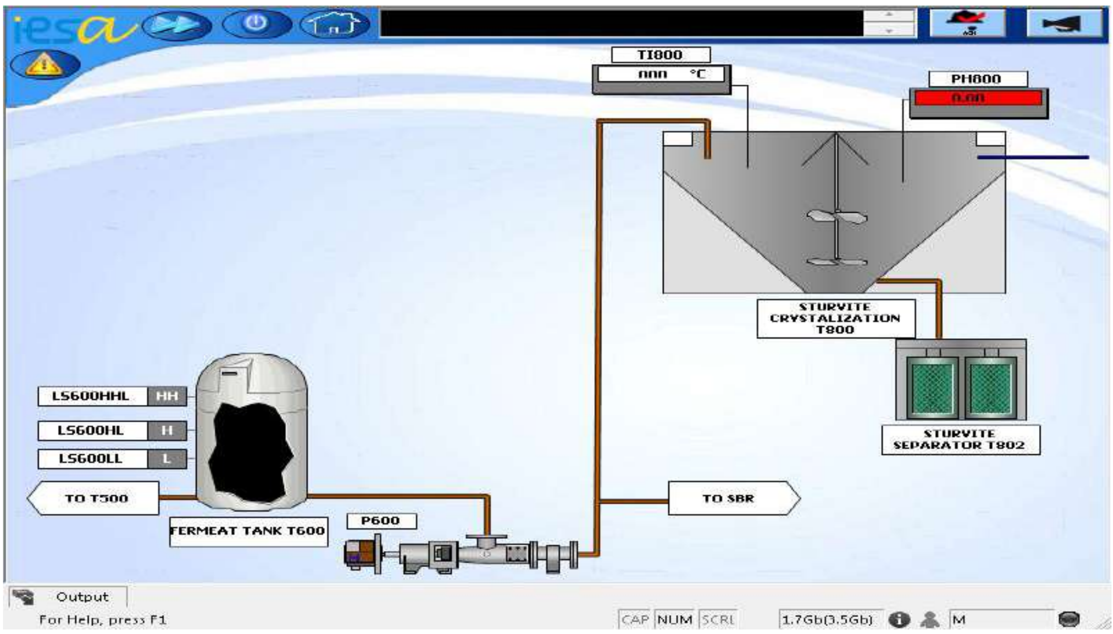


Figure 3: SCADA screen for SCR (Part of the SCADA screens).

Figure 4: Photo of the updated struvite crystallization reactor (SCR).

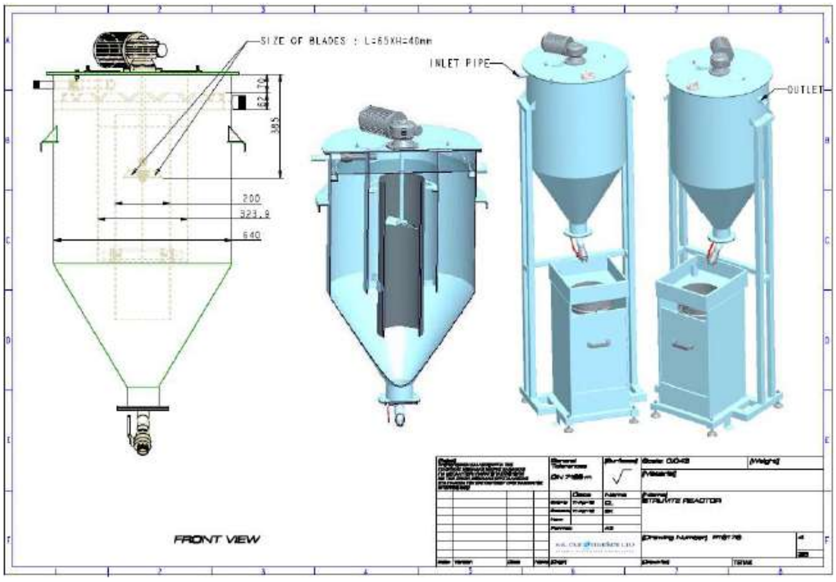


Figure 5: Front view design of the updated SCR from S.K Euromarket Ltd.

Main steps followed for struvite crystallization production.

The process followed for struvite crystallization was semi-batch. Struvite precipitation was performed in a 250 L continuous stirred reactor (tube-in-a tube reactor), consisting of three compartments.

The UF permeate was pumped from the accumulation tank (T600) through an eccentric screw pump (P600) on the top of the struvite crystallization reactor (T800) (Figure 3). The chemicals used for precipitation were phosphoric acid 85% w/w and magnesium hydroxide ≥95% (as a slurry) and were added in the middle compartment/tube of the reactor, where also the influent (UF permeate) was added.

The crystal retention time (CRT) was 4 days for crystal nucleation and growth. The mixing strength of the agitator was 50 s^{-1} (slow agitator). The agitator was placed in the inner tube in the middle of the reactor, so a slow recirculation takes place between the compartments of the reactor.

The crystallization reactor was filled with the UF permeate (250 L) and the estimated volume of the added chemicals was subtracted prior to their addition. The addition of chemicals was always kept in the same order. Firstly, the phosphoric acid was **slowly** pumped in the reactor (dosing pump P801) and then the magnesium hydroxide slurry was added through a peristaltic pump.

The magnesium hydroxide was mixed with water to form a milky solution. Because of its low solubility in water, it was vigorously stirred through a fast agitator before it was pumped in the middle compartment of the reactor. If magnesium hydroxide is not fully suspended, then there is an increasing probability of producing brucite and other precipitates instead of struvite. Since a pump was needed to add the milky solution into the reactor, an extra liter of our solution was produced than what was needed (15 L of magnesium hydroxide solution were needed, so we prepared 16 L).

Once chemical addition was completed, a two-hour interval was given for the solution pH to stabilize. Usually, a small quantity of sodium hydroxide 50% w/v is pumped (through the dosing pump P802) for the desired pH of 8,7 to be reached. The solution pH was monitored daily to ensure that It would not exceed 8.9 to avoid dissolution of struvite. In the event that it did, it was adjusted back to 8.7 with phosphoric acid 85% w/w.

After CRT of 4 days, the reactor was emptied and the struvite precipitate was harvested in filter bags and air-dried for approximately 2-3 days.

Financial analysis

The global organic fertilizer market is expected to grow with a Compound Annual Growth Rate (CAGR) of 12% from 2019 to 2024 (Research and Markets, 2021). Moreover, our leading-edge technology may result in a solid organo-mineral fertilizer of superior quality. Therefore, the proposed business can stand out from others and grow, despite the fertilizers' market competitive landscape (Technavio, 2021).

Generally, business investment in Cyprus is more attractive compared with other EU countries because of the low corporate tax rate (12.5%). Furthermore, Cyprus has one of the fastest-growing EU economies (EC, 2019). These facts provide an advantageous opportunity for businesses like the alternative fertilizers business to grow.

The following financial analysis considered the income and expenses of an industrial production plant, and all these were adjusted according to the cash flows, which ultimately gave us the economic projection.

The production process that is taken into account is the following: The centrifuged liquid digestate from the anaerobically treated mixed effluent (livestock waste and cheese whey waste) from Nicos Armenis & Sons will be settled utilizing a flocculant in a sedimentation tank (flocculation will facilitate the bonding of particles, thus creating larger aggregates that are easier to separate as they settle easily). Subsequently, the supernatant will be filtered through ultra-filtration ceramic membranes. Finally, the UF permeate will be subjected to struvite crystallization.

The initial development conditions of the industrial unit are the following:

- **Struvite crystallization batch:** every 3 days and total volume of reactor equal to 100 m^3.
- **Plant operating days**: 365 days/year
- **Yield of fertilizer**: 18 kg/ m^3 of total working volume (UF permeate plus reagents), resulting in 219 tn of struvite per year.
- **Liquid after struvite crystallization for irrigation**: Around 98 tn of liquid can be produced after struvite crystallization (working volume of the reactor equal to 100 tn). This liquid is enriched with valuable nutrients and micronutrients, essential for plant development. Moreover, this liquid's content in ammonium and phosphate is reduced by 45% and 95%, respectively compared to the UF permeate. This reduction can be sufficient to assist farmers to comply with the stringent regulations of various EU directives (including the Water Framework Directive 2000/60/EC, the Nitrates Directive 91/676/EEC, and the Waste Framework Directive 2008/98/EC).

In the case of Cyprus, it was taken into consideration that all the entire investment is made within the first year of operation, hence the plant goes immediately into production at its maximum capacity and performance. This is based on the fact that CUT has already acquired all the necessary knowledge to produce struvite, as well as the high demand for these types of fertilizers.

Revenues/Sales

This section considers the sales of the two products produced by the SCR: a) the struvite organo-mineral fertilizer and b) the liquid effluent produced following struvite crystallization, which may be used for irrigation (enriched liquid effluent).

Sale prices have been set as follow:

- **Struvite organo-mineral fertilizer**: A price of 400 €/tn was projected as struvite price, due to its superior quality and quantity of struvite per kg of precipitate, which is in line with the prices of similar fertilizers.
- **Enriched liquid effluent**: A selling price of 0.10 €/ m^3 was considered. This price is lower than that paid for water in most of the irrigation communities.

The transport cost to the final consumer is included in the final struvite price of 400 €/tn.

Table 1: Revenues from sales of the two products for the 1st year.

Production. YEAR 1			
Product	kg	€/kg	Subtotal (€)
Struvite	219,000	0.4	87,600
Liquid effluent	11,923,333.33	0.1	1192
TOTAL			88,792

- **Another considered revenue is the management service to the farmer**, which is the cost that is needed for a farmer to treat the waste to comply with current regulations. We have considered that the treatment cost will be 3 €/m^3 since we offer an advanced livestock waste treatment service.

Table 2: Other revenues from the 1st year of production (management service to farmer).

Other revenues. YEAR 1	
Description	€/year
Management service to farmer	36,500
TOTAL	36,500

These revenues result to a total annual income of approximately 125,292 €. **The estimated income for a period of 10 years is estimated equal to 1,288,716 €, considering that the price of the products will increase each year by 1% from the 4th year till the 10th year.**

Investment

The facilities to be built were considered in order to calculate the initial investment cost. The already built facilities of anaerobic digestion and centrifugation were not taken into account, since these belong to Nikos Armenis & Sons Farm and have been depreciated.

Hence, the following investment costs were taken into account:

- **Facilities cost**: Facilities costs are the costs for the supply of struvite crystallization reactor, tanks, equipment (pumps, agitators, sensors, controllers, ultra-filtration ceramic membranes, etc.), pipes, valves, etc. Except for the purchase of the necessary equipment and parts, a company with expertise in hydraulic connections, electrical installation, automatic and mechanical and technological works, is needed to assemble the entire plant. The facilities costs (Table 3) are estimated equal to 282,000 € (Table 3).
- **Building license**: The building license was estimated to be 3% of the total investment, so it is 8,460 € (in line with the range of 3-5%) (Table 4).
- **Design and dimensioning study**: A total cost of 7,000 € was considered for the implementation of the design and dimensioning study (Table 4).
- **Building project**: The fee of a civil engineer for the construction works was estimated at 3000 € (Table 4).

Table 3: Costs of facilities which is paid at once in the 1st year.

Facilities cost. YEAR 1			
Description	€/unit	nº units	Subtotal (€)
Sedimentation tank for 12.5 tn/day	5,000	3	15,000
Polymer preparation tank (tank 1 tn, agitator, pump 1000 L/hr)	2,000	3	6,000

Ultra-filtration ceramic membranes for 12.5 tn/day	35,000	2	70,000
Recirculation pumps for Ultra-filtration system	2,500	2	5,000
Ultra-filtration Buffer tank	4,000	2	8,000
Ultra-filtration permeate tank 20tn	6,000	6	36,000
Struvite crystallization reactor and slow agitator (50 tn)	40,000	2	80,000
Dosimetric pump 250 L/hr for sodium hydroxide and phosphoric acid	1,500	4	6,000
Ultra-filtration permeate pump	3,500	2	7,000
Magnesium hydroxide preparation tank (tank plus fast agitator)	2,000	2	4,000
Peristaltic pump	2,500	2	5,000
pH controller and pH sensor	2,500	2	5,000
pipes, check valves	5,000	1	5,000
Electrical installation, automatic works, plant assembly, mechanological works	20,000	1	20,000
Platform, shelter, and other structural works	10000	1	10,000
TOTAL			**282,000**

Table 4*: Taxes and project which is paid at once in the 1st year.*

Taxes and project	
Description	**€**
Building Licence	8,460
Design and dimensioning study	7,000
Building project	3,000
TOTAL	**18,460**

Loan evaluation.

The annual single installment for the loan repayment was estimated to be 35,223.08 €, taking into account an interest rate of 3% for sustainable businesses like this. This annual single installment is subtracted from the annual income. The loan repayment time will be 10 years and the total amount of mortgage is 300,460 €. So, the total amount of loan for 10 years along with the interest of 3% is 352,230.78 €.

Residual value

The residual value of the plant was estimated to be 30% of the initial value of the fixed assets (buildings, machinery, or transport tools). It is based on the average life of the fixed installations (10 years), the annual maintenance (10%), and two extraordinary maintenances of the less durable machinery (50%) in the 4th and 8th year. Following this maintenance practice in a 10 years-period, the fixed assets may be fully operational even in the 10th year and may be sold at a certain price.

The residual value is subtracted from the investment costs in the 10th year, in order to calculate the profitability of the project and the financial projection (IRR).

Table 5: Residual value for Cyprus' facilities.

Residual Value	
Facilities	€
Permanent facilities	262,000
Residual value rate	30%
TOTAL	78,600

Extra maintenance

Extra maintenance was also foreseen in the production costs, besides the ordinary maintenance (10% of the investment). This maintenance was calculated to take place the 4th and 8th year of operation and concerns the less durable machinery (50%). Following this practice, the plant may be amortized. Moreover, the plant will be in full operation even in the 10th year of operation and may be ensured that all the facilities will be functional for several more years.

Table 6: Extra-maintenance costs for the machinery of the Cypriot plant.

Extra Maintenance	
Facilities	€
Machinery	112,000
Residual value rate	50%
TOTAL	56,000

The overall investment costs for the construction of the plant are around 300,460 €, including taxes and project costs (Tables 3 and 4). **Summing up, the total investment costs for a period of 10 years were estimated to be 333,860 €, which include the amount of 300,460 €, the extra maintenance costs (Table 6), while the residual value is subtracted in the 10th year (Table 5).**

Production costs

The production costs are expected to vary depending on the quantity of liquid digestate that is utilized per year for pretreatment and struvite production.

Production costs include transport, reagents, consumables, electricity, insurances, facilities maintenance, and rent of the plot.

Transport costs

As far as the transport costs, the number of the required trips to deliver the struvite to the customers was estimated to 20 €, with each trip resulting in the delivery of 11 tons. The liquid effluent will be pumped in a truck, and the cost for its transport will be charged to the client, so it can be either an income or an expense.

Table 7: Struvite transport costs.

Transport. YEAR 1			
Concept	Trips/year	€/trip	Subtotal (€)
From Plant to Client	20	20	400
TOTAL			400

Consumables costs

The average required reagent quantities and their average prices (Alibaba, large suppliers base), which are used for this financial analysis are the following:

- Phosphoric acid (H_3PO_4) 85% w/w: Average dose: 4.8 L/m^3 UF permeate. Price: 85 €/tn.
- Magnesium hydroxide (99% purity): Average dose: 6.38 kg/m^3 UF permeate. Price: 165 €/tn. The water used for the preparation of the magnesium hydroxide slurry is not counted as a cost, since agricultural water from a drilling will be used.
- Sodium Hydroxide (NaOH) 50% w/w: Average dose: 1 L/m^3 UF permeate. Price: 85 €/tn (solution).
- Cationic polymer (purity 95%) for solid-liquid separation of liquid digestate: Average dose 1 kg/m^3 of liquid digestate: Price 255 €/tn.

Moreover, 200 € is the cost for filter bags per year for struvite draining and drying.

Table 8: Consumables costs for the 1st year.

Consumables YEAR 1			
Consumable	kg	€/kg	Subtotal (€)
Phosphoric acid 85% w/w	98,638	0.085	8,384.2 €
Magnesium hydroxide 99%	77,623	0.165	12,807.85 €
Sodium Hydroxide 50%	12,167	0.085	1,034.17 €
Polymer for solid liquid separation (purity 95%)	14600	0.255	3,723 €
Filterbags			200 €
TOTAL			**26,149.21 €**

Other production costs

- Energy: The required energy for the operation of the plant will be provided through the biogas production from the anaerobic digesters of Nikos Armenis & Sons Ltd farm.
- Insurance: The insurance of civil responsibility and the voluntary insurance of accidents at work were estimated to 2,000 € per year.
- Renting the plot. No renting costs were estimated since the plot is owned by Nikos Armenis.
- Facilities maintenance: Maintenance of the facilities is equal to the 10% of the total investment.

Table 9: Other production costs for the 1st year.

Other production costs. YEAR 1	
Name	Cost/year (€)
Insurances	2,000
Maintenance	28,200
TOTAL	30,200

Total production costs for the 1st year were equal to 56,749 €. **So, the total production costs for a period of 10 years were estimated to equal to 583,704 €, taking into account the 1% annual increase in the production costs, from the 4th year till the 10th year.**

Staff costs

Next, we will go over the personnel costs needed to support the operation of the pilot throughout the year. Following the experience that we acquired so far with the operation of the CUT pilot, we firmly believe that one qualified operator can manage all the struvite crystallization process, while one technician is required to perform the following tasks: electromechanical maintenance, automatist works, hydraulic connections, packaging, forklift operation, and part-time driving.

So, the required personnel is as follows:

- **Manager**: Qualified person for the supervision of the process and commercial relationship with customers and suppliers. It is considered that he/she will spend 10% of his/her time on this.
- **Operator**: An operator chemical engineer, qualified in the operation and management of the plant and its processes, can perfectly assume all the production foreseen. He/She will spend 40% of his/her time on this.
- **Technician**: One technician is needed for the implementation of all the required electromechanical maintenance of the equipment, automatist works, packaging, forklift operation, and part-time driving for products deliveries.

Table 10: Staff costs for the 1st year.

Staff cost. YEAR 1				
Position	€/month	% time	No. of months	Subtotal (€)
Manager	5,000	10	12	6,000
Operator/Chemical engineer	2,500	40	12	12,000
Technician	1,500	100	12	18,000
TOTAL				**36,000**

External assistance services

In addition, **several external services** are needed regardless of the production volume (fixed costs). These expenses are described as follow:

- **Analysis of the products obtained**: Chemical analysis to assure the quality of the products (struvite and enriched liquid effluent) will be performed weekly at a cost of 50 € and a total cost of 2600 €.
- **Accounting**: Will cost around 100 € monthly.

- **Marketing**: The marketing services in Cyprus are not very expensive, so a cost of 500 € per year is estimated to be sufficient to maintain the brand, a website, update social media, and make a small investment in local communication projects.
- **Labelling and packaging**: Labelling (prepare and print the labels) and packaging materials (supply of 25 kg bags, 50 kg bags, 250 kg bags, and a plastic tank of 1 tn) will cost around 500 €.

Table 11: External assistance costs for the 1st year.

External Assistance. YEAR 1	
Service	Cost/year (€)
Labs /Analysis	2,600
Accounting	1,200
Marketing	500
Labelling and packaging costs	500
TOTAL	**4,800**

Opportunity costs

The opportunity cost has been estimated equal to 4 €/m^3 since the offered service from this business will be of higher quality and quantity per kg of precipitate than from the competitive ones. The offered service will include the pretreatment of the liquid digestate with flocculation, sedimentation, and ultra-filtration. The obtained struvite from the proposed business will be of very high purity (up to 99.6 wt%). Moreover, the pretreatment with UF ceramic membranes ensures that the produced struvite does not contain pathogens, carcinogens, and heavy metals beyond the acceptable regulatory limits. So, it is a safe product for use, that meets the criteria set for solid organo-mineral fertilizer according to the Regulation EU 1009/2019.

Table 12: Opportunity costs for the pretreatment of liquid digestate pig slurry.

CURRENT Direct Costs. YEAR 1			
Position	m^3	€/m^3	Subtotal (€)
Liquid digestate pig slurry	12,167	4.00 €	48,666.67
TOTAL			48,666.67

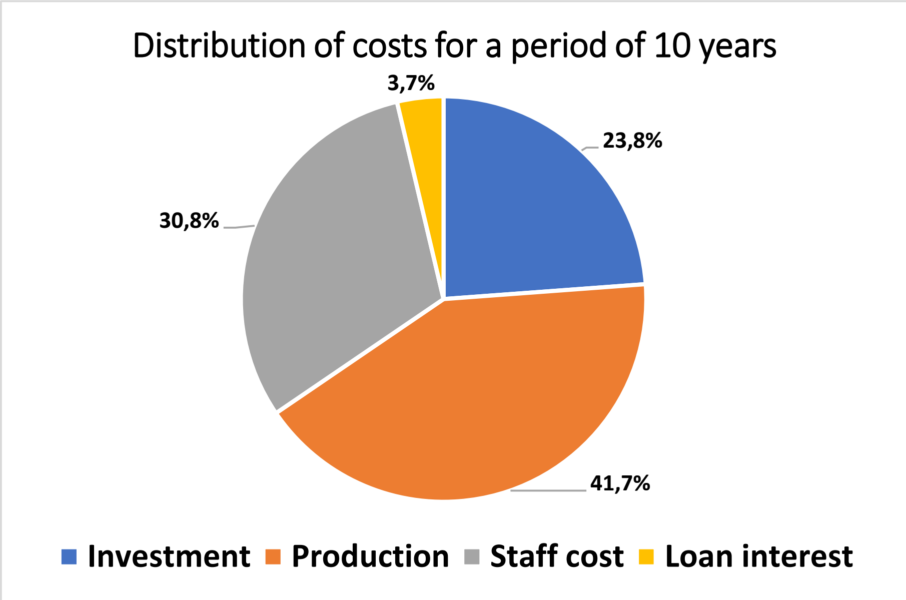
Profitability-Financial Projection

Considering all the revenues, expenses and variables listed and explained in this financial analysis we obtained an economically interesting financial projection. Its main potentialities are its low environmental impact and its high social impact.

Table 13: Cost-Benefit Analysis (€/year).

Year	Income	Investment	Production Costs	Staff Cost	Opportunity Cost	Cash-Flow	Acumulate Cash-Flow	Payback
1	125,292 €	300,460 €	56,749 €	40,800 €	48,667 €	-233,064 €	-233,064 €	-233,064 €
2	125,292 €		56,749 €	40,800 €	48,667 €	68,182 €	-164,882 €	-164,882 €
3	125,292 €		56,749 €	40,800 €	48,667 €	68,992 €	-95,890 €	-95,890 €
4	126,545 €	56,000 €	57,317 €	41,616 €	49,153 €	14,182 €	-81,707 €	-81,707 €
5	127,811 €		57,890 €	42,448 €	49,645 €	71,393 €	-10,314 €	-10,314 €
6	129,089 €		58,469 €	43,297 €	50,141 €	72,625 €	62,311 €	62,311 €
7	130,380 €		59,053 €	44,163 €	50,643 €	73,878 €	136,189 €	136,189 €
8	131,684 €	56,000 €	59,644 €	45,046 €	51,149 €	19,153 €	155,342 €	155,342 €
9	133,000 €		60,240 €	45,947 €	51,661 €	76,451 €	231,793 €	231,793 €
10	134,330 €	-78,600 €	60,843 €	46,866 €	52,177 €	156,372 €	388,165 €	388,165 €
SUM	1,288,716 €	333,860 €	583,704 €	431,785 €	500,569 €	388,165 €	387,942 €	387,942 €
			IRR	22.6%			PAYBACK (years)	7.74

Figure 6: *Distributions of costs for a period of 10 years.*



According to Figure 6, the production costs are estimated equal to 41.7% of the total costs for a period of 10 years. A percentage of 30.8% of the total costs is used to cover staff costs, while the investment costs hold 23.8% of the total costs for a period of 10 years. Overall, 3.7% of the total costs are attributed to the loan interest for a period of 10 years.

Economic conclusions

This report focused on the financial assessment of the pilot plant in Cyprus and its scalability potential to industrial scale. The treatment processes applied herein, result in products (solid and liquid) of superior quality that are safe for use. With the fertilizer market constantly growing and the stable economy of Cyprus that offers and the lowest corporate tax rate (12.5%) in the EU, there is room for growth.

The profitability of the investment was considered over a 10-year period, so that the true profitability of the investment was evaluated. A Return on Rate Investment (IRR) equal to 22.6% for a 10-year period is very attractive for private investors (an IRR higher than 18% is considered as opportunistic) (Ross S.A. et al., 1996), giving a great initiative to solve environmental problems related to livestock waste disposal. The 8th year (7.74 years) was estimated as the payback year. Considering that the required initial investment is not excessive, and the applied technology is simple, the proposed business results in a sustainable and profitable livestock waste management solution. Both the payback period and the IRR indicated that the investment is economically feasible and financially viable.

It is worth noting that the net present value (NPV) should also be evaluated, in order to avoid misleading projections by assessing only the IRR (Patrick M. and French N., 2016). The NPV (difference between the present value of cash inflows and the present value of cash outflows over a period of time) uses differences between all possible IRRs for an investment and its cost of capital, while the IRR considers the NPV to be zero. For example, if the present value of the expected cash outflows is less than the present value of the expected cash inflows, then NPV > 0. If NPV>0, then it is worth investing (Osborne M.J., 2010).

In any case, based on the financial analysis conducted above that took into consideration all costs and inputs, it becomes apparent that this is a scalable business that can turn profitable in a relatively short amount of time.

References

1. EC, 2019. Commission staff working document. Country Report Cyprus 2019. Including an In-Depth Review on the prevention and correction of macroeconomic imbalances. Available at: https://ec.europa.eu/info/sites/info/files/file_import/2019-european-semester-country-report-cyprus_en.pdf. Last accessed: 08/04/2021.

2. Osborne M.J., 2010. A resolution to the NPV–IRR debate? *Q. Rev. Econ. Finance*, 50, 2, pp. 234-239. Available at: https://doi.org/10.1016/j.qref.2010.01.002. Last accessed: 08/04/2021.

3. Patrick M. and French N., 2016. The internal rate of return (IRR): projections, benchmarks, and pitfalls. *J. Prop. Invest. Finance*, 34, 6. Available at: https://www.emerald.com/insight/content/doi/10.1108/JPIF-07-2016-0059/full/pdf?title=the-internal-rate-of-return-irr-projections-benchmarks-and-pitfalls. Last accessed: 08/04/2021.

4. Research and Markets, 2021. Organic Fertilizer Market: Trends, Forecast and Competitive Analysis. Report, April 2021. Available at: https://www.researchandmarkets.com/reports/5002837/organic-fertilizer-market-trends-forecast-and. Last accessed: 08/04/2021.

5. Ross S.A., Westerfield R., Jordan B.D., 1996. Essentials of Corporate Finance. 4th Edition, Irwin, p. 528. Available at: https://books.google.com.cy/books/about/Essentials_of_Corporate_Finance.html?id=OSNsiqRkOxkC&redir_esc=y. Last accessed: 08/04/2021.

6. Technavio, 2021. Phosphate Fertilizer Market by Application and Geography - Forecast and Analysis 2021-2025. Report, March 2021. Available at: https://www.technavio.com/report/phosphate-fertilizer-market-industry-analysis?utm_source=pressrelease&utm_medium=bw&utm_campaign=t42_KH_wk48_discount&utm_content=IRTNTR40718. Last accessed: 08/04/2021.

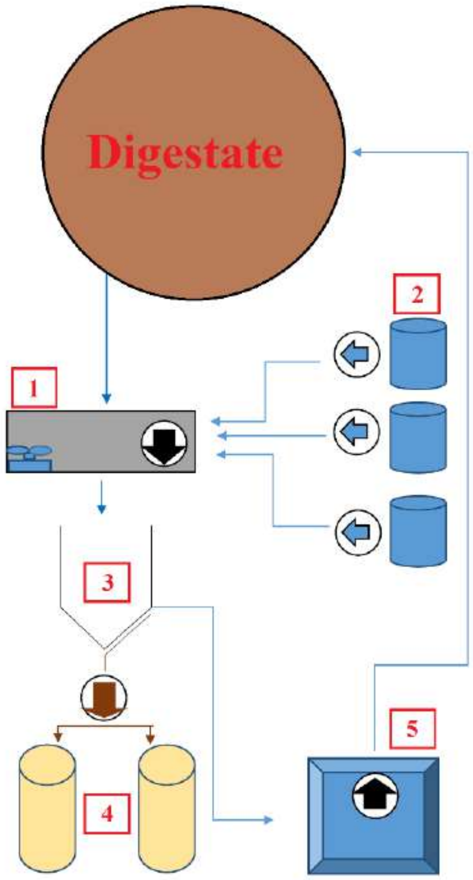
COST BENEFIT ANALYSIS (Italy)

Introduction

When the plants are installed as pilot or experimental, the evaluation of the overall efficiency of the industrial plants have as its main objective to identify, circumscribe and bring attention to their less than efficient conditions from a technical, financial and economic point of view of their day-to-day management. These analyses, therefore, fulfil the task of highlighting the issues to be fixed before the design and realization of a real industrial scale. The current assessments do not deviate from this general rule. The Arborea's pilot plant will be initially described in its chemical-physical and industrial process of digestate transformation until the organic precipitate and the final fluid component are obtained. Then, its problems and the necessary modification and solution intervention will be discussed. Finally, the financial analysis will be assessed. Its main parts are: the characteristics and issues of the investment; the description of the operating activities of the plant; the determination of the possible opportunity cost, to be considered as non-cash financial entities. The opportunity cost allows the management costs of the digestate, or the waste as such, to be reduced. It will be added to the revenues, although it does not give rise to any cash flow. Nevertheless, it reports the existence of indirect effects that would be better considered by the economic analysis. As refers to the latter, the present document does not contain it, as it could not yet rely on a financial analysis of a production plant complete in its technical and management components. The last paragraph draws attention to changes and further technical, management, industrial and market assessments to be developed in order to design a plant that is actually feasible. Once that all the suggested changes will be implemented, then there will be the conditions to perform the financial and the economic analysis.

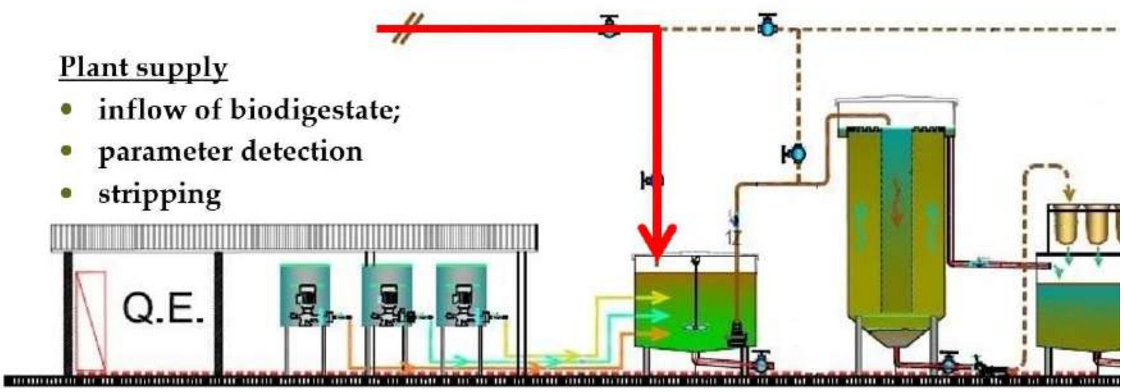
Process strategy

Technical details of the process (Plant scheme)



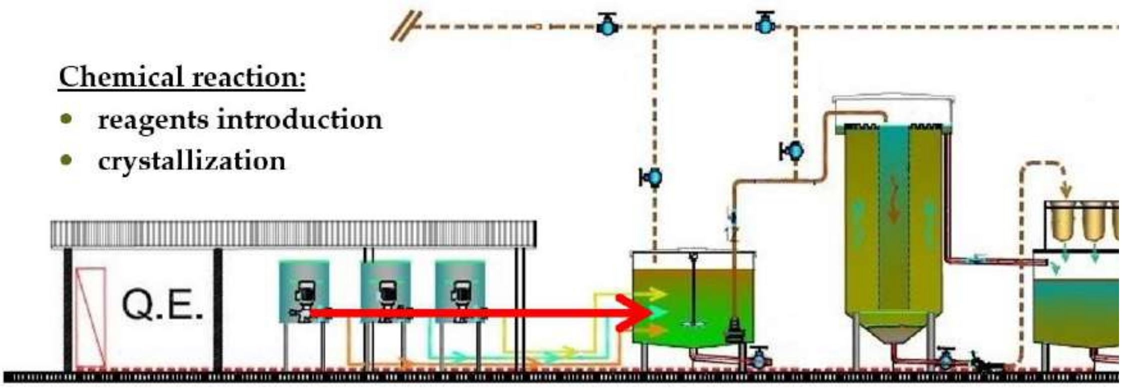
1. Reaction tank.
2. Reagents deposits and Dosing pumps
3. Fluidized bed settler.
4. Dewatering bags
5. Storage tank of the liquid fraction

Main steps



The first production phase consists in supplying the plant with 3.5 m^3 of digestate, which is poured directly from the solid / liquid separator installed in the storage tanks of the biodigester through a pipeline that carries the liquid fraction inside the reaction tank (1) without using electric pumps.

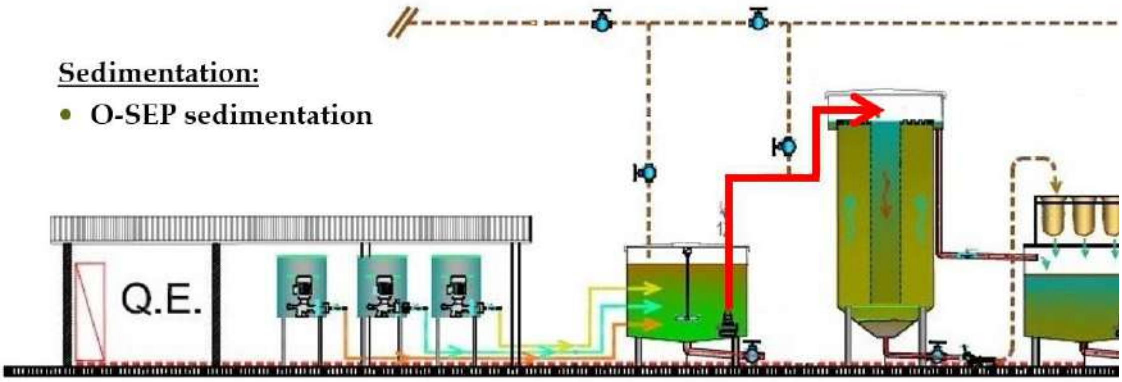
Once the reaction tank is full, then the mechanical stripping starts; it consists in moving any gaseous phases away from the liquid phase, especially carbon dioxide and ammonia. Stripping is obtained by running the electromechanical stirrer at 104 rpm for 30 minutes. Later on, you detect the necessary chemical parameter: the temperature, pH and concentration of the ammonium ion (NH_4^+).
Based on the amount of nitrogen detected, the quantities of phosphoric acid (H3PO4 to 75%) and magnesium chloride (MgCL2 at 47%) are calculated.



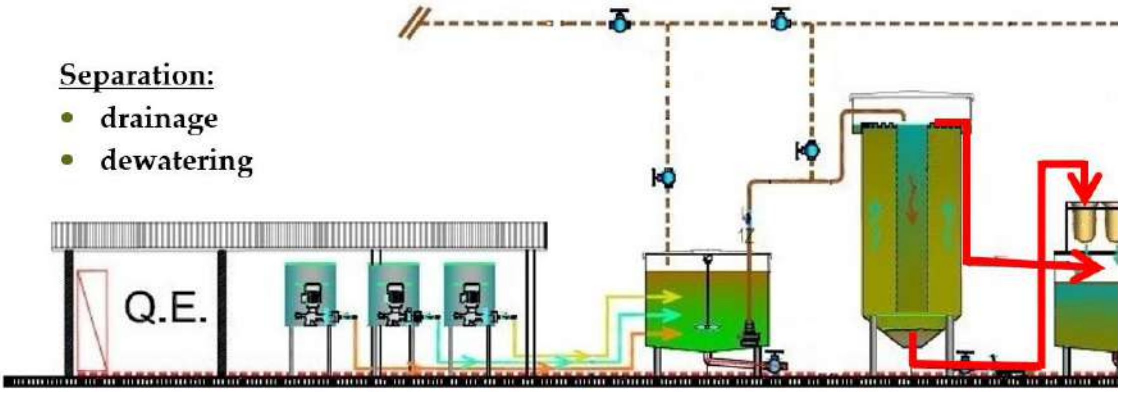
The second production phase begins with starting the stirrer at about 50 rpm. The speed is kept constant till the conclusion of the reagents' entry. Then, the anti-foaming is dosed and entered to reduce the formation of the foams, which originates from the chemical reaction of the acid with the carbonates present in the digestate.

The phosphoric acid and magnesium chloride are then introduced through the synchronised and timed activation of the dosing pumps (2). The pumps have known flow rates of 2,229 L/min and 2,200 L/min respectively. The two reagents introduction results in a sudden lowering of the ph. As soon as this phase ends, the last dosing pump to be activated is the sodium hydroxide (NaOH at 30%) one with a flow rate of 2,620 L/min and the pH is increased to about 8.9.

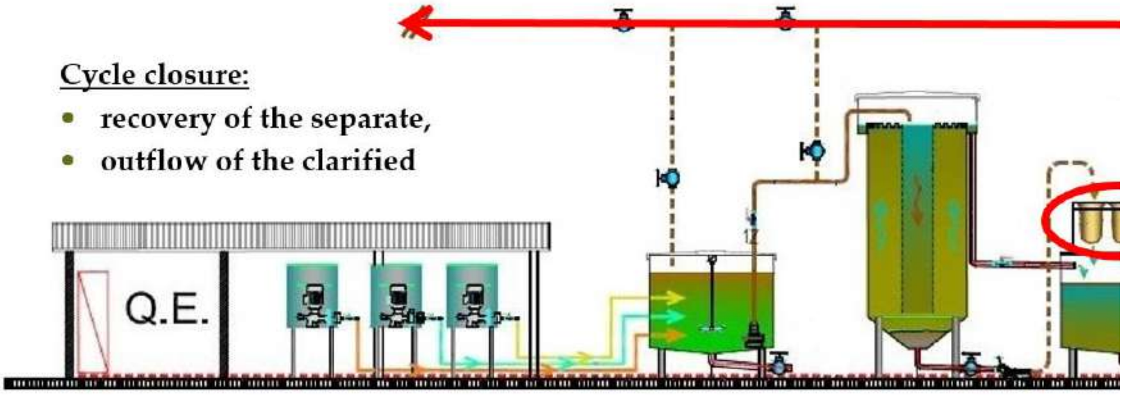
Once the necessary alkalinity has been obtained, the dosing pumps are turned off. To facilitate the precipitation/crystallization process, the treated matrix is kept under slight stirring, with a speed of about 25 rpm for 15-20 minutes. Finally, the matrix undergoes a rest/aggregation phase for about 15-20 minutes.



The third production phase concerns the sedimentation of the organic precipitate O-SEP. At the end of the reaction, the submersible pump installed in the reaction tank (1) is turned on to transfer the treated matrix into the fluidized bed settler (3). In the settler, the separation between precipitate and liquid fraction takes place. The O-SEP settles in the bottom while the liquid fraction (clarified) begins to flow from the upper part of the settler, pouring into tank C. The duration of the sedimentation varies from a few hours to a few days.



At the end of the sedimentation process, **phase 4 of the production process begins.** The single-brand pump is started to push the solid-liquid mixed fraction into the dewatering bags (4), which are placed above the clarified storage tank (5). The bags allow the separation between the liquid fraction (clarified) and O-SEP, keeping the struvite produced. The bags are left to drip the water that can be eliminated by gravity, after that they are removed from the top of the storage tank and kept at the reagent storage area until the water has completely evaporated and the O-SEP is obtained.



The fifth and final phase of the production process consists in the check of the chemical parameters of the clarified (5) to detect any residual nitrogen. Finally, the clarified contained in the storage tank is pumped through the submersible pump to the digestate storage tank.

Financial analysis

The financial analysis was performed taking into account of the real production capacities of our plant according to the technology adopted.

The following elements have been considered:

- Production: 3 batches of 3.5 m^3 for a total of 10.5 m^3 per day;
- Days worked: 300 days a year.
- O-SEP produced: 51 kg / m^3 (SERECO laboratory analysis);
- Average reduction level of NH4: 69.6%:

Revenue / Sales

The principle of prudence and all possible references have been followed in setting sales prices. The explanation for each of the products is as follows.

- Fertilizer enriched with struvite: currently (due to the legislation in force) there is still no real market for fertilizer enriched with struvite, so the price estimate must be theoretical and prudent. Furthermore, the price obtained in the struvite business model will depend on the degree of purity of this precipitate in the solid fertilizer obtained. The work of Li et al (2019)[6] contemplates prices between 300 and 800 USD/Tn. Westerman et al (2010)[7] considers 330 USD/Tn. The experts and the project partner SERECO propose an assessment between 200 and 400 €/Tn. In our case, the price calculated is 350 €/Tn. It is in line with the price of the fertilizers, which have similar characteristics except for the presence of struvite.

Production. YEAR 1			
Product	Kg or m^3	€/kg or €/m^3	Subtotal
Struvite (kg)	160 650	0,35 €	56 227,50 €
Liquid efluent (m^3)	6 615	- €	- €
		TOTAL	56 227,50 €

[6] Li, B., Udugama, I. A., Mansouri, S. S., Yu, W., Baroutian, S., Gernaey, K. V., & Young, B. R. (2019). An exploration of barriers for commercializing phosphorus recovery technologies. *Journal of Cleaner Production*, *229* 1342-1354.

[7] Westerman, P. W., Bowers, K. E., & Zering, K. D. (2010). Phosphorus recovery from covered digester effluent with a continuous-flow struvite crystallizer. *Applied engineering in agriculture*, *26*(1), 153-161.

Additional income:

- No subsidies from the public sector were considered.
- Taking into account the management structure of the fattening center, the hypothesis of a contribution from the biodigester management company is not considered feasible.

Investment

The calculation of the investment cost takes into account the construction costs of the facilities or the value of the ones already built.

Facilities cost. YEAR 1			
Description	€/unit	nº units	Subtotal
Structural works	18 713,50 €	1	18 713,50 €
Electrical instalation	6 621,57 €	1	6 621,57 €
Pipes	4 210,74 €	1	4 210,74 €
Valves	3 153,37 €	1	3 153,37 €
Agitator	500,00 €	1	500,00 €
Submersible pump	1 250,00 €	1	1 250,00 €
Mohno pump	2 150,00 €	1	2 150,00 €
Dosing station	8 200,00 €	1	8 200,00 €
External connections	- €	1	- €
Tank A	5 000,00 €	1	5 000,00 €
Settler B	14 000,00 €	1	14 000,00 €
Tank C	5 600,00 €	1	5 600,00 €
Frame for filter bags	500,00 €	1	500,00 €
Sensors	8 500,00 €	1	8 500,00 €
Safety and other charges	604,59 €	1	372,01 €
...			
		TOTAL	78 771,19 €

The following costs have also been considered:

- Construction licence: 800 €;
- Construction project: 7% of the investment;
- Assembly of the plant: the installation fee was included in the investment costs as per SERECO calculation;

Taxes and project	
Description	€
Building Licence	800,00 €
Building project	5 513,98 €
Plant Assembly	- €
TOTAL	6 313,98 €

Loan valuation

The valuation of the loan was performed considering a loan of € 85085.17, with a duration of 10 years, annual instalments calculated using the French method and an interest rate of 2.12%.

The interest rate used was obtained from "Banks and Money: National Series", published by the Bank of Italy on 10 March 2021. In particular, it refers to loans to non-financial companies with guarantees of up to € 1 million - new transactions: January 2021

Amount of mortgage >	**€ 85 085,17**	**Annual mortgage rate>**	
Duration of the loan (years) >	**10**	**Total interest expense>**	**€**
Number of installments in a year >	**1**		
Method of calculating the installments >	**Francese**		
Interest >	**2,12%**		

Sequential number	Residual debt	Principal repayments	Interest payments	S Inst
0	€ 85 085,17			
1	€ 77 355,73	€ 7 729,45	€ 1 800,32	€
2	€ 69 462,73	€ 7 893,00	€ 1 636,77	€
3	€ 61 402,72	€ 8 060,01	€ 1 469,76	€
4	€ 53 172,17	€ 8 230,55	€ 1 299,22	€
5	€ 44 767,48	€ 8 404,70	€ 1 125,07	€
6	€ 36 184,95	€ 8 582,53	€ 947,24	€
7	€ 27 420,82	€ 8 764,13	€ 765,64	€
8	€ 18 471,25	€ 8 949,57	€ 580,20	€
9	€ 9 332,31	€ 9 138,94	€ 390,83	€
10	€ -	€ 9 332,31	€ 197,46	€

Other consideration

We will apply a residual value of 35% over 10 years. The estimation is based on the average useful life of the fixed installations (10 years), and the two extraordinary maintenances at 4 and 8 years of the less durable machinery (12%).

Residual Value	
Facilities	€
Permanent fac.	52 313,50 €
Tase resid. value	35%
TOTAL	18 309,73 €

Extra Maintenance	
Facilities	€
Machinery	53 299,18 €
Tase EM. value	12%
TOTAL	6 395,90 €

Production costs

- Transport: no transport is foreseen for Arborea's plant.
- Consumables: the quantity of the reagents listed below is based on the real consumption recorded during the testing at the pilot
    - Phosphoric acid (73%) H_3PO_4. Average dose: 7,059 L/m^3, Density: 1,58 kg/L, Price: 1,43 €/kg
    - Magnesium chloride (50%). $MgCl_2$. Average dose: 6,536 L/m^3, Density: 1,34 kg/L, Price: 0,26 €/kg
    - Caustic Soda (30%). NaOH. Average dose: 29,082 L/m^3, Density: 1,34 kg/L. Price: 0,50 €/kg
    - Anti-foam agent. Average dose: 10 L/m^3, Density: 0,9 kg/L. Price: 3,10 €/kg
    - Filter bags: 30 kg/unit, Price: 3,40 €/unit

Considering the large amount of materials needed, the above prices have been discounted by 40%

Consumables. YEAR 1			
Name	kg or unit	€/kg or unit/€	Sub
Phosporic acid 73%	*35 133*	*0,86 €*	30
Magnesium chloride 47%	*27 588*	*0,16 €*	4
Sodium Hydroxide 30%	*122 755*	*0,30 €*	36
Antifoam agent	*28 350*	*1,86 €*	52
Filter bags	*5 355*	*2,04 €*	10
		TOTAL	134

Other P. Costs. YEAR 1	
Name	Cost/yea
Energy	1 927,87
Insurances	1 600,00
Renting	-
Maintenance	1 575,42
TOTAL	5 103,30

- Energy. The energy consumption has been calculated according to the timing of the different phases and the involved machineries. The entire process requires

2,5 kW/m^3, considering an expense of 0,25 €/kW[8], the cost per year is 1927,87 €;

- Insurance. Two different insurance are considered: the compulsory civil responsibility and the voluntary for accidents at work. The cost is approximately 1600 € per year;
- Rent of the pilot plant. No rent has been considered;
- Facilities maintenance. It has been calculated, following the principle of prudence, at 2% of the total investment per year.

Note: We have not considered indirect taxes (VAT). The purchase of the raw materials and the investment of the installations involve input VAT, but the sales of the final products involve output VAT. The only item that does not involve VAT is staff costs, so we will always have more VAT charged than borne (it improves our cash flow). The regulation of this tax is done every 3 months, so it has been considered more explanatory not to include it in the financial projection.

Personnel costs

This section considers the staff needed to maintain a plant of this size throughout the year. Despite the initial prevision, the testing procedures highlighted that the plant's management requires two (not one) operators to treat the established quantity of slurry (10,5 m^3/day).

Following the principle of prudence this section has been overestimated as follows[9]:

- 8° Level Technician. High qualified workers, endowed with specific skills, work at the strategic guidelines set up for the development and implementation of the company objectives. One of them was considered with a 5% commitment per year.
- 4° Level Technician. The national metalworkers contract includes at this level, the workers with technical-practical skills and knowledge that have been

[8] The Cost of electricity has been calculated for an industrial connection of a total power of 6 kW. The calculation was made on the online platform, offered by ARERA, for the comparison of the energy market offers. The established search characteristics are listed below:
Commodity: Electricity; Date: 22/03/2021; Type of offer: Fixed Price: Monorary Power level: 6 kW; Annual consumption: 8,500 kWh; Supply location: Arborea 09092.
The available offers were 310. A Random sampling was performed of 10 of the first 100 offers. The values are inclusive of all expenses and for them the VAT at 10% has been discounted.

[9] D.D. 56/2019 Ministry of Labor and Social Policies - Average hourly cost for personnel employed by companies in the private metalworker industry and plant installation (June 2019).

obtained through professional qualifications and internships. One of them was considered with a 30% commitment per year.

- 3° Level Technician. This level includes workers with diplomas from technical/professional institutes or with skills acquired in work experience. One of them was considered with a fulltime contract.

Professional expenses for external services have also been considered. They are fixed costs as they do not depend on the volume of production. The detailed list follows:

- Analysis of the products obtained. Every 2 weeks the fertilizer and the clarified produced are analysed. A cost of 100€ for product has been considered.
- Accounting. It has been considered an external cost of a professional company in tax and labor consultancy of 200 € per month.
- Marketing. Due to the local and nearby nature of the plant, the marketing costs should not be too much, even so it has been quantified a cost of 2,500 € per year to maintain the brand, the website, the social networks and to be able to make some small investment in local communication projects.

Staff cost. YEAR 1				
Position	Cost/month	% time	Nº months	Subt
Manager (8° Liv.)	4 028,21 €	5%	12	2 4
Technician (4° Liv)	2 919,74 €	30%	12	10 5
Technician (3° Liv.)	2 778,74 €	100%	12	33 3
			TOTAL	46 2

External Assistance. YEAR 1	
Service	Cost/year
Labs /Analysis	4 800,0
Accounting	2 400,0
Marketing	2 500,0
TOTAL	9 700,0

Opportunity costs

Arborea is an area vulnerable to nitrate, the digestate produced by the biogas plant is taken away from the area to be spread. After the treatment the liquid fraction will have a reduction of nitrogen (-70%), that is why the opportunity cost has been calculated considering the saving related to the reduction of travel. From the data provided by the Cooperative, an average reduction of about 25 km can be expected.

The transport was evaluated with the use of a tanker (semi-trailer) of about 18 m^3, for a total weight of over 26 tons, and a transport cost of € 2.34 / km, corresponding to € 3.25 / m^3 for 25 km.

CURRENT Direct Costs. YEAR 1			
Position	m^3	€/m^3	Subtotal
Digestate	3 150	3,25 €	10 237,50 €
			- €
		TOTAL	10 237,50 €

Profitability. Financial Projection

Year	Cash Receipts	Investment	Production Costs	Staff Cost	Opportunity Cost	Cash-Flow	Acumulate Cash-Flow	
1	56 227,50 €	85 085,17 €	140 032,64 €	55 972,93 €	10 237,50 €	-216 426,06 €	- 216 426,06 €	-
2	56 227,50 €	- €	140 032,64 €	55 972,93 €	10 237,50 €	-131 177,34 €	- 347 603,40 €	-
3	56 227,50 €	- €	140 032,64 €	55 972,93 €	10 237,50 €	-131 010,33 €	- 478 613,72 €	-
4	56 789,78 €	6 395,90 €	141 432,97 €	57 092,39 €	10 339,88 €	-139 090,82 €	- 617 704,54 €	-
5	57 357,67 €		142 847,29 €	58 234,23 €	10 443,27 €	-134 405,65 €	- 752 110,20 €	-
6	57 931,25 €		144 275,77 €	59 398,92 €	10 547,71 €	-136 142,97 €	- 888 253,17 €	-
7	58 510,56 €		145 718,53 €	60 586,90 €	10 653,18 €	-137 907,32 €	-1 026 160,48 €	-1
8	59 095,67 €	6 395,90 €	147 175,71 €	61 798,63 €	10 759,72 €	-146 095,06 €	-1 172 255,55 €	-1
9	59 686,62 €		148 647,47 €	63 034,61 €	10 867,31 €	-141 518,97 €	-1 313 774,52 €	-1
10	60 283,49 €	-18 309,73 €	150 133,94 €	64 295,30 €	10 975,99 €	-125 057,50 €	-1 438 832,02 €	-1

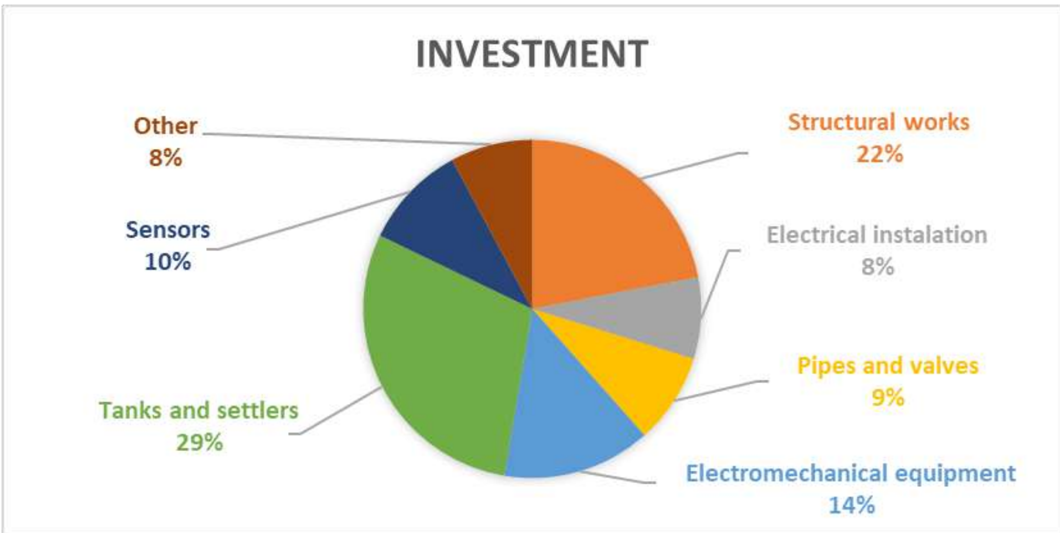
Under the present conditions the project is not financially feasible. In particular, it is noted that the costs of consumables are excessively high.

Economic conclusions

The following evaluations were carried out on the basis of the data collected during the construction and management phase of the pilot plant. Therefore, the relationships and balances between investments, production volumes and operating costs are those of a plant whose technology and organization will have to be modified to comply with the requirements of an industrial plant.

The Investment

The investment for the construction of the pilot plant at the "Coop. Producers of Arborea" has a total cost of € 85085.17. From the total cost the residual value of the plant in the tenth year of the time horizon has to be deducted. The investment determines an estimated production of 160650 kg of organic separate enriched in struvite (O-SEP) obtained by treating 3150 m3 of digestate.



In addition to the technical parameters, the experimental size of the plant can be verified also from an economic point of view. In fact, analysing the cost breakdown among the various items, the investment costs related to sensors, which is indirectly attributable to the automations typical of an industrial apparatus, are about 18% of the total cost, compared to carpentry works 22% of expenditure on structural works and 29% of tanks and settler respectively.

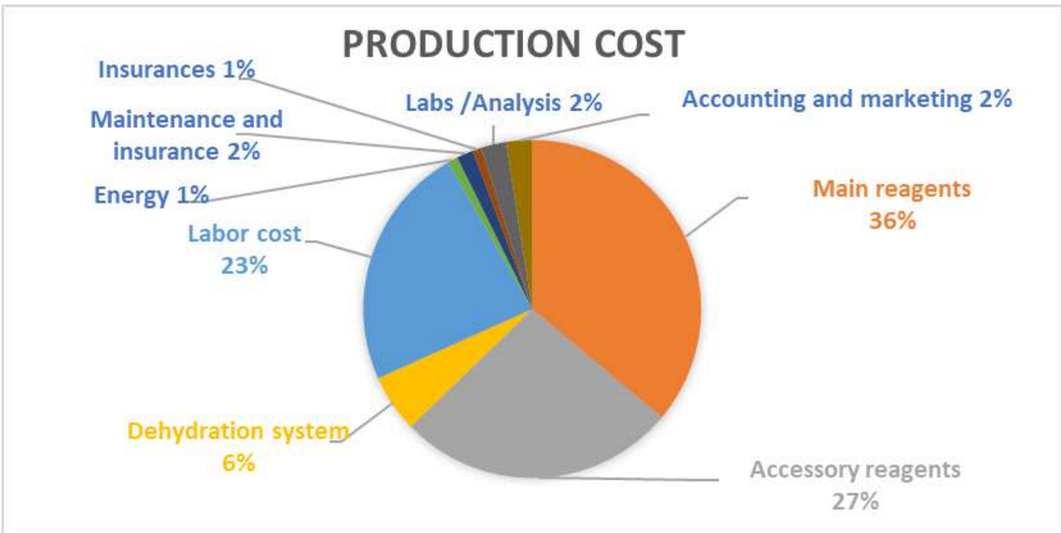
The implementation of the plants on an industrial scale requires an increase in the investment of all the items mentioned above. In particular, electromechanical and sensory works. They are necessary for the automation of the plant, which allows the simultaneous operation of the various technical/ productive phases. In fact, the present setting of the pilot plant grants the completion of the individual phases only in sequence, since in the reaction tank other phases take place: the storage, stripping, and crystallization.
In order to increase the daily production of the plant, it would be profitable to carry out the different phases simultaneously, obtaining a "continuous" treatment rather than for individual cycles. This is because the single-cycle requires a long execution time.

The production costs

As highlighted above, the crucial technical and financial crux of the project lies in the total production costs (197605,57 €/y) compared to the expected revenues (56227,50 €/y). The following chart shows that the main production costs are: the reagents (main and secondary) 124005.14 €/y; the labour cost 46272,93 €/y; they represent 63% and 23% of the total costs respectively.

The described production model was designed with a technological simplification due to the funds assigned by the Re-LIVE WASTE project to the plant construction. The amount of the funding determined the investment. The simplification affected the performance of some production technologies and techniques included in the production process, which, in addition, proved to be extremely expensive.

The detailed analysis of the higher production costs, therefore, offers insights for evaluating the operations necessary to make the production process more efficient, in a technical and financial sense.



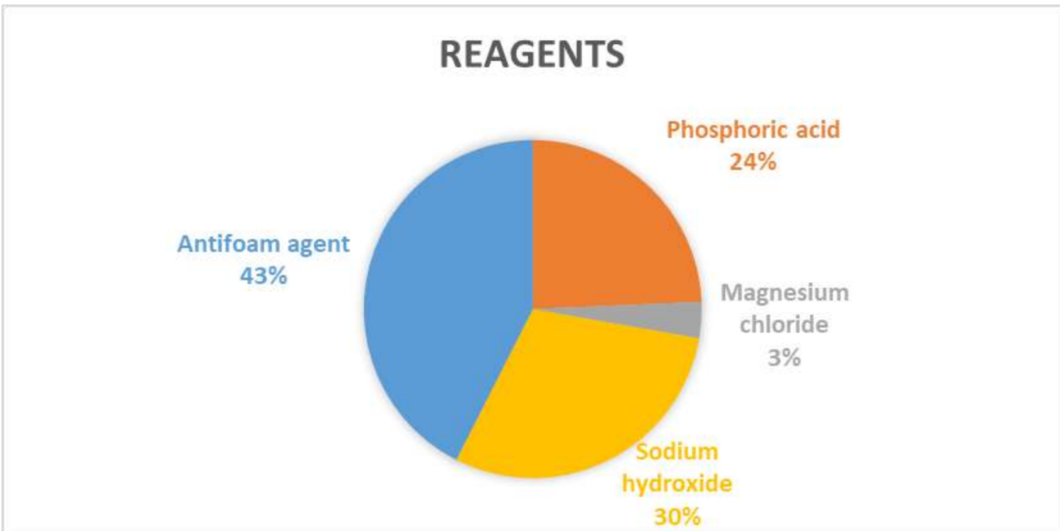
The reagent's cost:

The use of refined and expensive chemical reagents, together with their high quantities, causes an excessive volume of expenditure, if compared to the revenues from the sale of the O-SEP. By analyzing these costs, it is possible to trace this source of inefficiency to the use of phosphoric acid.

The introduction of the acid into the chemical-physical process of transformation of the digestate has two main effects: it reacts with the carbonates dissolved in the same organic matrix and by releasing carbon dioxide, forms large amounts of foam; it lowers the pH. To offset these chemical reactions is necessary on the one hand, to introduce the antifoam, which accounts for 43% of the total expenditure. On the other hand, to add the sodium hydroxide to reach the basicity values necessary for the crystallization of struvite, 27% of total reagent spending. These two reagents, antifoam and sodium hydroxide add up to 70% of the total cost.

It would be useful to look for alternative sources of phosphorus, which might be cheaper, have fewer acid reactions and possibly come from the reuse / recycling of this element, in an eco-friendly process.

Among the recycling sources of phosphorus there are: bones deriving from slaughterhouse waste, with content of phosphoric anhydride ($P2O5$) ranging from 16.51% of fish bones to 22.90% of the pig; ashes deriving from the burning of waste from the wood industry, with a phosphorus content between 1.3 and 20%, or residues from the steel industry such as Thomas slag, with a total phosphorus pentoxide content varying between 12 and 23%. Finally, other sources are salts. They contain phosphorus such as potassium hydrogen phosphate ($K2HPO4$), or potassium dihydrogen phosphate ($KH2PO4$), and are commercially available in the crystallized form at lower prices than the phosphoric acid used in the experiment.



Labour costs:

To reduce the labour costs, it is necessary to reinforce the automation of the plant. These would lead to a reduction of the hours and the number of workers. For example, the installation of a PLC that automatically controls, through solenoid valves, timers, adequate sensors and a suitable dehydration system would reduce the need for the labour force to a single worker, with the task of monitoring the functionality of the system and the success of the production process.

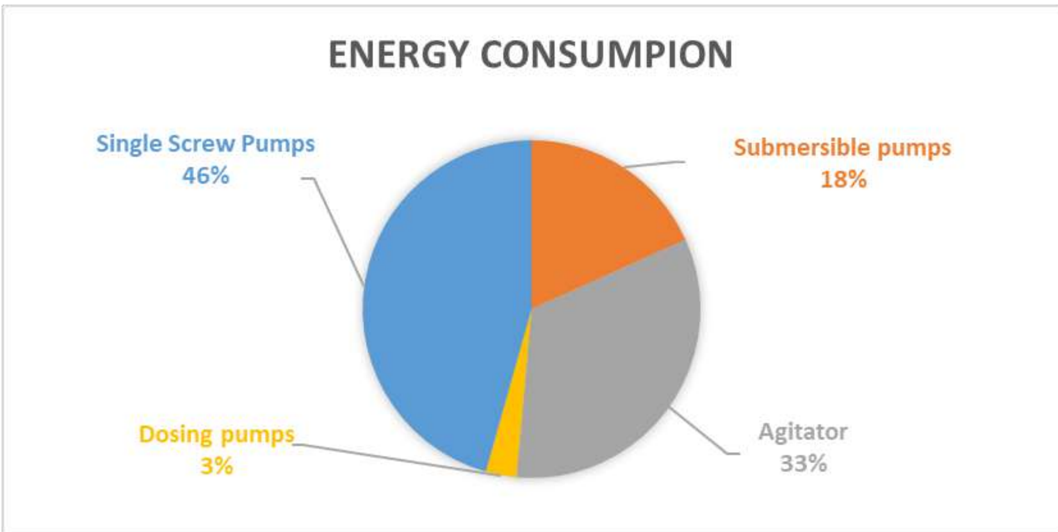
Dehydration system:

The use of filter bags, as a dehydration system for O-Sep, proved to be technologically and operationally not very efficient; although it does not negatively affect production costs. This system mainly focused on gravity drainage and air drying, is not sufficiently performing for the typical timing of an industrial production process. It follows that in the scaling up hypothesis, the filter bags must be replaced, for example, with a thermo-mechanical dehydration technology. Nevertheless, if on the one hand, there would be a reduction in costs for the purchase of filter bags, on the other hand, there would be an increase in electricity consumption.

At present it is difficult to evaluate the possible costs and revenues deriving from the acceleration of the production process, as the present analysis is based on the experience of a pilot plant.

Energy consumption:

As explained in the production cost's section, the entire process is not expensive from an energy point of view. Among the different electromechanical devices, the greatest energy consumption is due to the sludge pumping system and the stirring system of the reaction tank, as shown in the following graph.



The choice of more technologically advanced solutions could lead to a further reduction in energy costs. Among the possible alternatives, an air insufflation system could be installed to replace the stirrer in the stripping phase which generates energy savings, as it requires a lower electricity consumption.

Concluding remarks

In conclusion, the findings obtained through the construction and operational management of the pilot plant have highlighted those that currently seem to be the main lines of action to improve and define the structure and operation of an industrial plant of struvite production. At this stage, it is possible to compare the unit production cost of the O-Sep with the unit market value of the fertilizer. The difference between the two 1.16 euros/kg of the production cost and 0.35 euros/kg of the selling price, clarifies the stage of progress of the Arborea pilot plant project compared to its final version. Based on the present findings, it is necessary to reduce production costs by at least 3.3 times to make the production process economically profitable.

Selling price	*Production cost*
€/kg	€/kg
0,35 €	1,16 €

This comparison is for the moment disadvantageous, but it must be accompanied by the recognition of a number of actions, such as those briefly mentioned above, which are all achievable and feasible.
They could enable a new assessment of the production and management structure to make it financially favourable. At that point, the overall efficiency of the investment would be strengthened by the economic analysis, once the benefits and interests of the community have been considered.

COMMON RISKS AND ENTRY BARRIERS

Throughout this Economic Assessment document, the different risks, current barriers to entry and conclusions have been listed and developed. Most of these risks are framed in two main aspects: the state of maturity of the technology and the current European regulations concerning biofertilizers in general and struvite in particular.

In this section we will summarize in a SWOT all these risks and possible barriers, as well as their solutions and potential.

On the other hand, we are going to list the main critical factors that condition the economic viability of a plant using this technology.

SWOT analysis

Weaknesses

Lack of homogeneity in the substrates Not only are livestock by-products of different animal species produced, but within the same animal species, the manure produced between one farm and another can be very different. This is mainly due to the management of the farm by the farmer and has a very direct effect on the concentration and quantity of reagents to be used. It also conditions that the final products have a different characterization depending on the initial raw material

Livestock sector with individualistic tendencies. To start up projects to obtain fertilizers with this technology, in most cases, a group of farmers is needed who can make a joint investment or at least treat their slurry in the same plant. This entails an added difficulty since the livestock sector is traditionally a sector with few cooperative structures especially for the management of its by-products.

Cost of the process very dependent on the price of the reagents. It is necessary to obtain the reagents from by-products of other industries. With this and the collective purchase this very direct incidence would no longer have a strong influence. For example, in the Spanish case, Magnesium Chloride has been replaced by Magnesium Oxide. The latter comes from a mining industry and its management is a problem for them. The purchase price has been much lower, and this has helped to improve the profitability of the plant. This is a path that should be further explored.

The state of development of technology is still in a process of improvement and adaptation. Several pilot plants and some small installations have been carried out but more mature technology is needed and even to combine this technology with other existing and proven slurry management technologies to obtain more sustainable processes

Threats

Lack of regulations governing the production and marketing of struvite as developed in the initial part of this document, there are proposals and actions in the EC aimed at regulating the production, marketing and use of struvite as a fertilizer. These processes are complex and there is a real risk that they will take longer than initially planned. This would lead to a significant delay in the development and implementation of the technology, which could lead to its abandonment for several years, which is crucial for the development of alternative technologies.

The EC is working on a new EU Regulation to regulate this product, but it will eventually be up to each Member State to officially approve its use and marketing in that State. This situation leads to the risk that in some Member States it can be produced and marketed and in another it cannot (this is already happening at present). The difference in time to implement and improve the technology in the different EU countries carries the risk of leaving the last countries to regulate this legal aspect out of the market.

Development of other technologies. The versatility and therefore adjustment of this technology for each of the by-products treated, as well as the lack of legislation regulating it, may lead to other alternative technologies being developed earlier and with better results that address the same problem, leaving this development out of play.

Innovation as an entry barrier. The struvite is an innovative product and still little known by its end users. Like all innovative products, it needs time to be exposed, matured and demonstrated until it can reach the market. The great threat is that the livestock sector does not have that time.

Strengths

The production process of struvite from livestock by-products is a simple process, based on a chemical reaction and is well known. For each by-product to be treated, the molar ratios of the reagents must be adjusted, but once this ratio has been defined, there is practically no risk of failure in the process.

The installations needed to carry out the chemical process are not sophisticated, do not require a large investment and in many of the current farms existing installations can be used: tanks, rafts, pipes, impulsion pumps...

The product obtained allows the recovery of nitrogen and phosphorus present in the slurry and also recovers it in a way where its storage, transport and reuse are much easier and beneficial for the farmer and/or grower.

Much less agricultural area is required to manage the slurry on farms as fertilizer. Since the release of nitrogen and phosphorus present in the struvite precipitate is slow and, moreover, does not wash away with the leaching, the same amount of slurry can be poured onto a much smaller agricultural area.

Modular and compatible process. The technological process of obtaining struvite-enriched precipitate is a modular process, that is, it can be started with a small amount of treated slurry and as more m^3 are required, only more storage tanks need to be added or the facilities need to be operated for more hours. The investment to increase the capacity of the plant is low and the technological complexity is very low.

Opportunities

It is a technology compatible with organic farming. The trend towards this type of agriculture on the part of the consumer and the policies aimed at promoting it constitute a unique opportunity to implement these processes in many rural areas of the MED territory

Regulations on organic fertilizers. As mentioned above, current European fertilizer policies tend to eliminate mineral-based fertilizers as opposed to those based on biological elements. This is our case.

Regulations on struvite. It has also been mentioned above that the EU is working on a regulation to regulate the production, marketing and use of struvite as a bio-fertilizer. It is a slow process and asymmetric by countries, but it is undeniable that it is in progress and will be achieved in the short to medium term.

Circular Economy-Bioeconomic. These two concepts, which are interrelated, form part of the policies and themes to be supported and promoted by the EU and its Member States. This means that any project that uses RE-LIVE Waste technology will have many possibilities of getting public funding or support for its implementation.

The current, very restrictive regulations on nitrates and others of a more national or regional nature are a great boost for the implementation of this technology. Farmers need simple, sustainable and easy-to-apply technologies to comply with increasingly demanding environmental regulations that limit their livestock activity.

KEY FACTORS

There are several factors to consider when scheduling the installation of a slurry management plant using this technology. The main key factors are:

- ✓ Size of the plant. A minimum volume is required depending on the cost of personnel, raw materials and facilities. Estimates for a pig slurry treatment plant have been 50 m^3/day. Of course, the greater the volume of treatment, the better the economy of scale, although the transport and proximity of the by-products to the plant must always be considered (maximum recommended radius 30-40 km).
- ✓ Type of raw material. Obviously, it is not the same to treat pig slurry (90% water) as another type of slurry or a mixture of slurry with another type of waste (digestate). All of this will condition the size of the plant, its profitability and management. The richness of struvite in the resulting precipitate and the greater or lesser use of reagents is causally related to the initial composition of the raw material to be treated
- ✓ Location of the plant. The transport of the raw material and the resulting products is essential to involve the farmers (suppliers) and customers (farmers). Therefore, it is convenient to install the plant in areas of high livestock density. Transporting livestock by-products is much more expensive than transporting the resulting precipitate, so it is very convenient to install the plant where it is most convenient for the farmers who are going to supply the material to be treated.
- ✓ Quality of by-products. Depending on the type of by-product to be treated, some pre-treatments or others will be required. Any pre-treatment that reduces the % of water to be transported and therefore more richness of products in the plant will directly influence the profitability of the plant
- ✓ Maturity of technology. This technology should be used for raw materials already tested and with the molar and chemical relationships tested and refined. The initial advice of experts in this field can have a very important influence on the short to medium term profitability of the plant

ANNEX 1: FINANCIAL TOOL

In this simple financial tool is a complement to the deliverable that can be used by users to make a first estimate of the viability of their project. Most of the calculations are automatic, if there are doubt in filling in the cells you can consult the details of the four case studies developed in the project.

Entity	

Production. YEAR 1			
Product	Kg	€/kg	Subtotal
Struvite			
Liquid efluent (m3)			
		TOTAL	- €

Othes Revenue. YEAR 1	
Description	€/year
Grant from local authority	
Management service to farmer	
TOTAL	- €

Production. YEAR 2			
Product	Kg	€/kg	Subtotal
Struvite			
Liquid efluent (m3)			
		TOTAL	- €

Othes Revenue. YEAR 2	
Description	€/year
Grant from local authority	
Management service to farmer	
TOTAL	- €

Production. YEAR 3			
Product	Kg	€/kg	Subtotal
Struvite			
Liquid efluent (m3)			
		TOTAL	- €

Othes Revenue. YEAR 3	
Description	€/year
Grant from local authority	
Management service to farmer	
TOTAL	- €

Entity	

Facilities cost. YEAR 1			
Description	€/unit	nº units	Subtotal
Structural works			0
Electrical instalation			0
Pipes			0
Valves			0
Agitator			0
Submersible pump			0
Mohno pump			0
Dosing station			0
External connections			0
Tank A			0
Settler B			0
Tank C			0
Aditional structures			0
Sensors			0
Collection trolley			0
...			- €
		TOTAL	- €

Previous Facilities cost. YEAR 1			
Description	€/unit	nº units	Subtotal
Tank for subirrigation			0
Storage tank			0
Dry System			0
Existing rook and platfrom			0
Homogeneization tank			0
			- €
			- €
			- €
			- €
			- €
			- €
			- €
			- €
			- €
			- €
			- €
		TOTAL	- €

Taxes and project	
Description	€
Building Licence	- €
Building project	
Plant Assembly	
TOTAL	- €

Residual Value	
Facilities	€
Permanent fac.	- €
Tase resid. value	30%
TOTAL	- €

Extra Maintenance	
Facilities	€
Machinery	- €
Tase resid. value	50%
TOTAL	- €

Facilities cost. YEAR 2			
Description	€/unit	nº units	Subtotal
Tank 10 m3			- €
Pump			- €
Electrical instalation			- €
...			- €
		TOTAL	- €

Previous Facilities cost. YEAR 2			
Description	€/unit	nº units	Subtotal
Slurry raft			- €
Storage tank			- €
...			- €
			- €
		TOTAL	- €

Facilities cost. YEAR 3			
Description	€/unit	nº units	Subtotal
Tank 10 m3			- €
Pump			- €
Electrical instalation			- €
...			- €
		TOTAL	- €

Previous Facilities cost. YEAR 3			
Description	€/unit	nº units	Subtotal
Slurry raft			- €
Storage tank			- €
...			- €
			- €
		TOTAL	- €

Entity	

Amount of mortgage >	- €	Annual mortgage rate>	10
Duration of the loan (years) >	10	Total interest expense>	- €
Number of installments in a year >	1		
Method of calculating the installments >	Francese		
Intrest >	2,75%		

Sequential number	Residual debt	Principal repayments	Interest payments	Single Installment
0	- €			
1	- €	- €	- €	- €
2	- €	- €	- €	- €
3	- €	- €	- €	- €
4	- €	- €	- €	- €
5	- €	- €	- €	- €
6	- €	- €	- €	- €
7	- €	- €	- €	- €
8	- €	- €	- €	- €
9	- €	- €	- €	- €
10	- €	- €	- €	- €
			- €	

Entity	

Transport. YEAR 1			
Concept	Trips/year	€/trip	Subtotal
From Farm to Plant			- €
From Plant to Client			- €
			- €
			- €
		TOTAL	- €

Consumables. YEAR 1			
Name	kg	€/kg	Subtotal
Phosporic acid 73%			- €
Magnesium oxide 50%			- €
Sodium Hydroxide 30%			- €
Fliter Bags			- €
		TOTAL	- €

Other P. Costs. YEAR 1	
Name	Cost/year
Energy	
Insurances	
Renting	
Maintenance	- €
TOTAL	- €

Transport. YEAR 2			
Concept	Trips/year	€/trip	Subtotal
From Farm to Plant			- €
From Plant to Client			- €
			- €
			- €
		TOTAL	- €

Consumables. YEAR 2			
Name	kg	€/kg	Subtotal
Phosporic acid 73%			- €
Magnesium oxide 50%			- €
Sodium Hydroxide 30%			- €
Fliter Bags			- €
		TOTAL	- €

Other P. Costs. YEAR 2	
Name	Cost/year
Energy	
Insurances	
Renting	
Maintenance	- €
TOTAL	- €

Transport. YEAR 3			
Concept	Trips/year	€/trip	Subtotal
From Farm to Plant	*750*	- €	- €
From Plant to Client	*64*	- €	- €
			- €
			- €
		TOTAL	- €

Consumables. YEAR 3			
Name	kg	€/kg	Subtotal
			- €
			- €
			- €
			- €
		TOTAL	- €

Other P. Costs. YEAR 3	
Name	Cost/year
Energy	
Insurances	
Renting	
Maintenance	- €
TOTAL	- €

Partner	*LA UNIÓ DE LLAURADORS I RAMADERS*

Staff cost. YEAR 1				
Position	Cost/month	% time	Nº months	Subtotal
Manager				- €
Technician				- €
Technician				- €
				- €
			TOTAL	- €

Staff cost. YEAR 2				
Position	Cost/month	% time	Nº months	Subtotal
Manager				- €
Technician				- €
Technician				- €
				- €
			TOTAL	- €

Staff cost. YEAR 3				
Position	Cost/month	% time	Nº months	Subtotal
Manager				- €
Technician				- €
Technician				- €
				- €
			TOTAL	- €

External Assistance. YEAR 1	
Service	Cost/year
Labs /Analysis	
Accounting	
Marketing	
TOTAL	- €

External Assistance. YEAR 2	
Service	Cost/year
Labs /Analysis	
Accounting	
Marketing	
TOTAL	- €

External Assistance. YEAR 3	
Service	Cost/year
Labs /Analysis	
Accounting	
Marketing	
TOTAL	- €

Entity	

CURRENT Direct Costs. YEAR 1			
Material	m3	€/m3	Subtotal
Pig Slurry			- €
		TOTAL	- €

CURRENT Direct Costs. YEAR 2			
Material	m3	€/m3	Subtotal
Pig Slurry			- €
		TOTAL	- €

CURRENT Direct Costs. YEAR 3			
Material	m3	€/m3	Subtotal
Pig Slurry			0
		TOTAL	- €

Entity	

Year	Income	Investment	Production Costs	Staff Cost	Opportunity Cost	Cash-Flow	Acumulate Cash-Flow	Payback
1	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
2	0 €		0 €	0 €	0 €	0 €	0 €	0 €
3	0 €		0 €	0 €	0 €	0 €	0 €	0 €
4	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
5	0 €		0 €	0 €	0 €	0 €	0 €	0 €
6	0 €		0 €	0 €	0 €	0 €	0 €	0 €
7	0 €		0 €	0 €	0 €	0 €	0 €	0 €
8	0 €	0 €	0 €	0 €	0 €	0 €	0 €	0 €
9	0 €		0 €	0 €	0 €	0 €	0 €	0 €
10	0 €		0 €	0 €	0 €	0 €	0 €	0 €

Price Increase per year	*1%*
Prod. Costs increase per year	*1%*
Staff Cost increase per year	*2%*
Opport. Cost increase per year	*1%*

IRR **#NUM!**

PAYBACK (years) **#DIV/0!**