RE-LIVE WASTE

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

https://re-livewaste.interreg-med.eu

Project co-financed by the European Regional Development Fund

RE-LIVE WASTE IN NUTSHELL

B&H Case study

NOTE

This document (or report) is not an official publication and has not been subjected to its standard editorial procedures.

This document is the result of the activities of the entire RE-LIVE WASTE project team. Responsible persons and leading institutions of individual activities are clearly indicated at the beginning of each chapter.

FAFS RE-LIVE WASTE team expresses deep gratitude to all participants in the project.

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MED

(2014 - 2020)

Application Form

AF_2_Modulaire

Priority axis-Investment Priority-Specific Objective 1-1-1

Priority Axis 1: Promoting Mediterranean innovation capacities to develop smart and sustainable growth PI 1.b

1.1 To increase transnational activity of innovative clusters and networks of key sectors of the MED area

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

Submitted version by UNISS, Sassari, Italy (Project coordination isntitution)

MED Contact

13 boulevard de Dunkerque Immeuble Grand Horizon 13002 Marseille FRANCE Provence-Alpes-Côte d'Azur Bouches-du-Rhône

Tel:

Fax:

Email: programme_med@regionpaca.fr

- I - PART A - Project summary

1. A.1 Project identification

Acronym			RE-LIVE WASTE	
Project title			Improving innovation capacities of private and public actors for sustainable and profitable REcycling of LIVEstock WASTE	
Name of the Lead Partner organisation			University of Sassari	
Project Nb			2974	
Duration of the project	Starting date		2017-12-01	Number of months
	Ending date		2020-05-31	30
Programme priority axis			Priority Axis 1: Promoting Mediterranean innovation capacities to develop smart and sustainable growth	
Programme specific objective			1.1 To increase transnational activity of innovative clusters and networks of key sectors of the MED area	
Call for projects			2nd modular call - single module	
Type of project			Testing	
Internal ref number			1488189243	

2. A.2. Project short description

Agriculture and livestock are key sectors in the MED area. Regions involved in the project are characterized by intensive cattle and pig livestock farming, producing large amounts of waste that represent a major source of pollution, an environmental challenge for society and an economic problem for farms. There is a great unexploited potential for MED regions to spread the use of innovative technologies that convert livestock waste into resource. RE-LIVE WASTE tests innovative solutions for livestock waste management in selected MED regions, taking into account technical, environmental, economic and legal aspects. Project pilot actions will transform livestock waste into organic high-value commercial fertilizers (as Struvite), contributing to smart and sustainable growth and to the creation of new businesses and market opportunities. Project outputs include 4 demonstrative Struvite Precipitation (SP) plants, a comparative analysis on the results achieved by the 4 case-studies including technical, agronomic, environmental and economic aspects; policy guidelines to stimulate innovation adoption and to set-up a common suitable legal framework. The transnational network creation aims at sharing innovative technologies able to reduce ecological footprint of livestock sector. Involvement of actors of quadruple helix and a beneficiaries-oriented approach ensure a concrete impact on involved territories and transferability of results to other EU regions.

- II - PART B - Project partners

1. B.1. Project partners

Partner number	Profile	Status
LP1	Chef de file	Active
Identification number of the organisation		2050
Name of the partner		University of Sassari
Abbreviation of the organisation		UNISS
Main adress		Piazza Università 21 07100 Sassari
Service		Desertification Research Centre
Adress of the service		Viale Italia, 39 07100 Sassari
NUTS3		Sassari
NUTS2		Sardegna
Country		ITALY
Eligibility zone		MED Partner
Outside of the programme area		No
Category		Higher education and research
Type of administrative code		[en] VAT identification number
National idenfifying number		00196350904
Is your organisation entitled to recover VAT?	No	
Legal status		Public
Role of the partner in the project		
2007–2013 programming period participation		No
Total staff of the partner structure		
Partner number	Profile	Status
PP1	Partenaire	Active
Identification number of the organisation		4321
Name of the partner		Murcia Institute of Research and Development
Abbreviation of the organisation		IMIDA
Main adress		IMIDA, Calle Mayor s/n 30150 La Alberca
Service		Department of Livestock Production
Adress of the service		

NUTS3		Murcia
NUTS2		Región de Murcia
Country		SPAIN
Eligibility zone		MED Partner
Outside of the programme area		No
Category		Business support organisation
Type of administrative code		Tax Identification Number (TIN)
National idenfifying number		ESS3000012I
Is your organisation entitled to recover VAT?	No	
Legal status		Public
Role of the partner in the project		Operational
2007–2013 programming period participation		Yes
Total staff of the partner structure		100 to 199
Partner number	Profile	Status
PP2	Partenaire	Active
Identification number of the organisation		2100
Name of the partner		Cyprus University of Technology
Abbreviation of the organisation		CUT
Main adress		30 Archbishop Kyprianos 3036 Lemesos Facebook - https://www.facebook.com/CUTofficial Twitter https://twitter.com/cutaccy You Tube - https://www.youtube.com/channel/UCYgPdWWp7FZguifTCdu kDJA
Service		Department of Environmental Science and Technology
Adress of the service		
NUTS3		Κύπρος
NUTS2		Κύπρος
Country		CYPRUS
Eligibility zone		MED Partner
Outside of the programme area		No
Category		Higher education and research
Type of administrative code		VAT identification number
National idenfifying number		CY90002687H
Is your organisation entitled to recover VAT?	No	
Legal status		Public

Role of the partner in the project		
2007–2013 programming period participation		Yes
Total staff of the partner structure		
Partner number	Profile	Status
PP3	Partenaire	Active
Identification number of the organisation		4130
Name of the partner		Sarajevo Economic Regional Development Agency
Abbreviation of the organisation		SERDA
Main adress		Kolodvorska 6 71000 Sarajevo
Service		
Adress of the service		
NUTS3		BOSNIA AND HERZEGOVINA
NUTS2		BOSNIA AND HERZEGOVINA
Country		BOSNIA AND HERZEGOVINA
Eligibility zone		IPA Partner
Outside of the programme area		No
Category		Sectoral agency
Type of administrative code		[en] N° gestion interne
National idenfifying number		200186600000
Is your organisation entitled to recover VAT?	Yes	
Legal status		Public
Role of the partner in the project		
2007–2013 programming period participation		Yes
Total staff of the partner structure		
Partner number	Profile	Status
PP4	Partenaire	Active
Identification number of the organisation		3277
Name of the partner		Faculty of Agriculture and Food Sciences
Abbreviation of the organisation		
Main adress		Zmaja od Bosne 8 71000 Sarajevo
Service		Zootehnical Institute
Adress of the service		

NUTS3		BOSNIA AND HERZEGOVINA
NUTS2		BOSNIA AND HERZEGOVINA
Country		BOSNIA AND HERZEGOVINA
Eligibility zone		IPA Partner
Outside of the programme area		No
Category		Higher education and research
Type of administrative code		Administrative identification number
National idenfifying number		4200091870006
Is your organisation entitled to recover VAT?	Partially	Equipment purchasing and services through projects financed by the international funds are acquitted of a VAT. In this case, it must seek approval for each individual project of the Ministry of Civil Affairs of Bosnia and Herzegovina and European Commission's Delegation to Bosnia and Herzegovina. A condition is a signed contract for project activities.
Legal status		Public
Role of the partner in the project		Operational
2007–2013 programming period participation		No
Total staff of the partner structure		100 to 199
Partner number	Profile	Status
PP5	Partenaire	Active
Identification number of the organisation		6781
Name of the partner		[en] ALIA Agricultural transformation society
Abbreviation of the organisation		ALIA
Main adress		Cmno. Del Duende 14. Dip. La Hoya 30816 lorca
Service		R+D+I department. Quality control and food security Area
Adress of the service		
NUTS3		Murcia
NUTS2		Región de Murcia
Country		SPAIN
Eligibility zone		MED Partner
Outside of the programme area		No
Category		SME (micro, small, medium enterprise)
Type of administrative code		Tax Identification Number (TIN)
National idenfifying number		ESF30030753
Is your organisation entitled to recover VAT?	Yes	
Legal status		Private

Role of the partner in the project		
2007–2013 programming period participation		No
Total staff of the partner structure		
Partner number	Profile	Status
PP6	Partenaire	Active
Identification number of the organisation		6928
Name of the partner		Fertilizers and Ecological Nutrients-FYNECO
Abbreviation of the organisation		
Main adress		Plaza del Pirineo 14 30507 Molina de Segura
Service		The technical-researcher area (I+D)
Adress of the service		
NUTS3		Murcia
NUTS2		Región de Murcia
Country		SPAIN
Eligibility zone		MED Partner
Outside of the programme area		No
Category		SME (micro, small, medium enterprise)
Type of administrative code		Tax Identification Number (TIN)
National idenfifying number		ESB73870032
Is your organisation entitled to recover VAT?	Yes	
Legal status		Private
Role of the partner in the project		
2007–2013 programming period participation		No
Total staff of the partner structure		
Partner number	Profile	Status
PP7	Partenaire	Active
Identification number of the organisation		1740
Name of the partner		LAORE Sardegna - Regional Agency for Agriculture Development
Abbreviation of the organisation		LAORE Sardegna
Main adress		Via Caprera 8 09123 CAGLIARI
Service		Service sustainability of livestock activities and fish - Organizational Unit Support to the sustainable management of livestock farms and fish

Adress of the service		
NUTS3		Cagliari
NUTS2		Sardegna
Country		ITALY
Eligibility zone		MED Partner
Outside of the programme area		No
Category		Regional Public authority
Type of administrative code		Fiscal code
National idenfifying number		03122560927
Is your organisation entitled to recover VAT?	No	
Legal status		Public
Role of the partner in the project		Institutional
2007–2013 programming period participation		Yes
Total staff of the partner structure		50 to 99
Partner number	Profile	Status
PP8	Partenaire	Active
Identification number of the organisation		3722
Name of the partner		Sereco Biotest snc di Luca Poletti
Abbreviation of the organisation		
Main adress		Via C.Balbo, 7 06121 PERUGIA
Service		
Adress of the service		
NUTS3		Perugia
NUTS2		Umbria
Country		ITALY
Eligibility zone		MED Partner
Outside of the programme area		No
Category		SME (micro, small, medium enterprise)
Type of administrative code		[en] VAT identification number
National idenfifying number		00289900540
Is your organisation entitled to recover VAT?	Yes	
Legal status		Private
Role of the partner in the project		Operational

2007–2013 programming period participation		No
Total staff of the partner structure		1 to 4
Partner number	Profile	Status
PP9	Partenaire	Active
Identification number of the organisation		2047
Name of the partner		Ministry of Agriculture, Rural Development and Environment
Abbreviation of the organisation		MOA
Main adress		28th October Strt, No. 20-22 2414 Engomi
Service		Sector of Pollution Control
Adress of the service		
NUTS3		Κύπρος
NUTS2		Κύπρος
Country		CYPRUS
Eligibility zone		MED Partner
Outside of the programme area		No
Category		National Public authority
Type of administrative code		VAT identification number
National idenfifying number		CY90002700J
Is your organisation entitled to recover VAT?	No	
Legal status		Public
Role of the partner in the project		Institutional
2007–2013 programming period participation		No
Total staff of the partner structure		

- III - PART C – Project description

1. C.1 Project relevance

1.1 C.1.1 What are the common territorial challenges that will be tackled by the project? Are they coherent with the programme specific objective selected and the relevant Terms of Reference of the call?

MED regions involved in RE-LIVE WASTE (in IT, ES, CY, FBH) are characterized by intensive cattle and pig livestock farming, producing large amounts of waste that need to be effectively managed. In these regions the livestock sector has undergone a deep transformation during the past 40 years, reporting an upward trend in intensification and larger farm units (even if in FBH the sector is still characterized by high fragmentation and lower productivity compared to EU-average). Agriculture and livestock have become key sectors of the MED economy, which managed to grow and increase employment rates even during the recent economic crisis. Livestock production accounts for 30% of agricultural production in Murcia and for more than 35% of value added in Cyprus. In FBH cattle production is about 214.000 heads, whereas in Sardinia has become the main agro-food industry with €135M sales. However, livestock production is also a major source of pollution in these regions, in particular of GHGs emissions and nitrate leaching in groundwater. Livestock effluents, used as fertilizers by farmers, cause severe problems in terms of soil and ground water pollution. EU Nitrates Directive limited their use for environmental reasons, with a relapse in terms of increased management problems for farms. An overall-effective livestock waste management represents a main major challenge for MED regions. RE-LIVE WASTE focuses on the transformation of waste into high-value fertilizers by testing innovative processes in 4 regions. The project's relevance is in line with Priority axis 1 and Specific objective 1 since the testing will offer a great opportunity for innovation adoption, knowledge sharing, transfer and networking among the regions. Moreover, the demonstration of the agronomic and environmental performance of the fertilizers obtained as well as their commercial viability will influence their marketability, contributing to the creation of new market and business opportunities.

1.2 C.1.2 What is the project's approach in addressing these common territorial challenges and/or joint assets and what is new/specific about the approach the project takes?

The project will test innovative technologies to be implemented in case studies, and that can be widespread throughout the MED area. The project addresses the regions' livestock waste management challenges following an integrated and sustainable approach built on the recycling principle "from waste to high-value commercial products". The project follows a comprehensive approach, focusing on strengthening innovation capacity of involved SMEs and on results transfer to public actors, reinforcing transnational cooperation and knowledge-sharing among 4-helix actors in the MED area. 4 case studies have been identified in project territories, and 4 pilot actions will be implemented for testing innovative technologies and eco-friendly processes. Firstly, the pilots will set-up/upgrade small-scale plants for struvite precipitation by means of a high-efficient cutting edge crystallizator able to effectively perform the abatement of recovery of nitrogen alongside with phosphorous, allowing farmers to comply with the Nitrates Directive as well as to improve the “Nutrient Use Efficiency” of their farming activities. Secondly, the pilot actions will be evaluated from an agronomic and environmental perspective and commercial viability of fertilizers obtained will be assessed. Thirdly, a transfer plan will stimulate public actors in formulation of policies which can incentive the adoption of innovations tested. Project builds on networking: SMEs, research bodies, public authorities, sector organizations, industry and other stakeholders will be actively involved in the project from the very beginning. New networks of stakeholders will be established as well as linked to already existing networks at regional and transnational level, in order to transfer know-how and widely disseminate the results. The demonstrative characteristics of the project allows project outputs to have concrete impacts on the involved actors and territories and to be transferred to other EU regions.

1.3 C.1.3 Why is transnational cooperation needed to achieve the project’s objectives and result?

Livestock waste management has become a focal issue in relation to current EU and national policies on environmental, climate, waste handling and renewable energy matters and its optimization is a key challenge for the EU, especially the MED area. The complexity of livestock waste management requires a transnational approach in order to support the sustainable growth of the livestock sector in the MED area. Some regions have already implemented innovative and efficient strategies to tackle this challenge, while others are still behind, due to lack of knowledge or limiting policies. In order to cover the knowledge gap and overcome policy restrictions, the transnational approach adopted by the project is strictly necessary. RE-LIVE WASTE will develop a transnational cooperation network among 13 partners(including 3 associated) from 4 MED countries which share common problems in the management of livestock waste from intensive farming. The geographical distribution of partners involved in the project gives the opportunity to compare results from the 4 testing pilots, share experiences, exchange expertise and learn from one another taking into account the different levels of innovation adoption and development throughout the MED area. The transnational approach of the project is crucial since it allows to test and transfer knowledge on innovative technologies and processes that transform livestock waste into high added-value organic fertilizers, that otherwise won’t spread to all involved regions. Since the project also aims to demonstrate the commercial viability of the fertilizers obtained in order to develop a concrete market for these products, a transnational cooperation action is necessary to demonstrate all their potential and to eliminate the barriers (e.g. legislative) that may impede its future development. This will contribute to the creation of new business and job opportunities not only in the MED regions, but in the EU as a whole.

1.4 C.1.4 Please confirm wich cooperation criteria apply to your project.

	Cooperation criteria
Cooperation criteria	Joint Development Joint Implementation Joint Staffing Joint Financing

1.5 C.1.5 Why the type of project (module) selected is appropriate in order to achieve the objectives of the project?

RE-LIVE WASTE is a M2-Testing project, based on the previous experiences and scientific research conducted by all partners in their national contexts. Some project territories have been involved in previous projects concerning the livestock waste management, but there is currently an urgent need for testing innovative technologies, in order to deal with the identified environmental and economic constraints. Thanks the implementation of the testing activities, livestock waste can shift from a disadvantage (environmental problem and management costs) to a valuable resource for the wide agriculture sector. The

testing module will permit to implement pilot activities for concretely transforming the livestock waste into a valuable fertilizer. The technology proposed has been already validated and project territories will take advantage of it. Testing is designed in the perspective of setting-up solutions applicable to a wider set of MED territories. The evaluation of the pilot actions will permit to identify strengths of the solutions tested, in terms of socio-economic and environmental benefits. Pilot activities will stimulate the adoption of these innovative solutions by other EU livestock SMEs, for the profitable re-use of livestock waste. The phase of transferability of the results in the territories will aim to support public actors in the formulation of policies that incentive the adoption of innovations proposed. 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 (IMIDA, Laore, MOA), 2 specialized companies (SERECO and FYNECO), a regional sectoral agency (SERDA), 4 livestock SMEs (ALIA, Animalia Genetics, Cooperativa Produttori Arborea, PD Butmir).

2. C.2 Project focus

2.1 C.2.1 Project objectives, expected results and main outputs

Project general objective
Project's overall objective is to improve innovation capacities of public and private actors involved in the management of waste from intensive livestock farming, through stronger cooperation among the 4-helix actors. The project contributes to Programme Sp. Obj. 1, targeting 2 key sectors in MED regions(agriculture and livestock), by favouring innovations' application, which will make the livestock sector more productive, sustainable and competitive. RE-LIVE WASTE aims at supporting a sustainable green growth, with a specific focus on Waste management, by transforming livestock waste into a high-value resource and by creating new business opportunities. The conversion of waste into high-value commercial fertilizers (an increasingly important issue for different stakeholders, i.e. farmers, technology providers, investors, industry and decision makers) is addressed by the project through a transnational network and by the design of a shared strategy to raise awareness. The achievement of this objective contributes to promote sustainable growth in the MED area by fostering innovative technologies, as well as a profitable and smart resources management. The project is in line with the OECD and EU green growth strategy: it aims at valorizing waste while focusing on cost-effective ways for reducing related environmental impacts. RE-LIVE WASTE contributes to reach the EU2020 strategy, addressing the targets related to employment, innovation, but also climate change and energy.
Project result
1 Three Small-scale pilot plants for the production of valuable fertilizers installed and functioning; 1 existing Small-scale pilot plant upgraded : The results of the pilot activities (3 Small-scale pilot plants for the production of valuable fertilizers installed and functioning; 1 existing Small-scale pilot plant upgraded with the introduction of technical innovations) will concretely offer innovative instruments to livestock SMEs involved in the project in order to improve their innovation capacities and opportunities to transform waste from an economic and environmental problem, to a valuable resource in the form of an organic, commercial and eco-friendly fertilizer. These results will support the achievement of the first output indicator of the programme (1.1 a- Number of operational instruments to favour innovation of SMEs).

2 Provided support to policies formulation that can incentive innovation adoption : In order to achieve the output programme indicator regarding the number of enterprises receiving grants (1.1 b) in the future, it is necessary to support public actors in elaborating policies that can effectively incentive and stimulate innovation adoption by SMEs in the field of livestock waste management. This will be done thanks t the elaboration of policies guidelines (D. 4.5.1), which will be presented and discussed during regional thematic round tables (D.4.5.2), to EU policy makers, to DG Agriculture and rural development, DG Environment, DG Grow, and will also be available in the web site. In addition, they will be presented to the Committee of the Regions, Conference of Peripheral Maritime Regions, Association of European Border Regions, Assembly of European Regions, the Council of European Municipalities and Regions, the European Consortium of the Organic-Based Fertilizer Industry (ECOFI), the European Commission's Fertilisers Working Group , Copa-Cogeca (representing European farmers and European agri-cooperatives), and FAO- Committee on Agriculture. These policies should include recognition of Struvite fertilizer in the EU legislation, as well as incentives as fiscal incentives, tax breaks, rewarding criteria for innovative SMEs and clusters. 3 regional and 1 national authorities are directly involved in the project as full partners.
3 Constitution of a transnational network to create synergies with innovation clusters : RE-LIVE WASTE will contribute to the output programme indicator 1.1d through: - The project will increase awareness of SMEs about their role as key actors for the local development, means of transnational activities andproviders cross-border services. - The constitution of a transnational network including a wide variety of stakeholders can lay the foundation for the establishment of a newinnovation cluster - Networking activities can trigger cooperation and synergies with other transnational innovation cluster already present in the MED area.

Specific Objective of the Programme		Result indicator	
1.1 To increase transnational activity of innovative clusters and networks of key sectors of the MED area		Share of innovative clusters (i.e. including RDI activities) offering to their members a consolidated mix of transnational activities in key sectors of the MED area	
Title of the objective	**Description**	**Communication objectives**	**Approche/tactics**
Stimulate private actors in the adoption of innovations for the profitable re-use of waste deriving from the livestock productive chain	Stimulation and support for innovation adoption to SMEs will be achieved through different outputs: - Output 3.1: 4 innovative demonstrationplants producing organic fertilisers (Struvite); - Output 3.2: Comparative analysis on theresults achieved by the 4 case-studies including technical, agronomic, environmental and economic aspects These outputs will be presented during the transferring phase (D.4.3.1, D.4.4.1, D.4.6.1). They will contribute to the programme output indicators 1.1.a. and 1.1.c	- Raise awareness of private actors aboutthe innovations to be adopted for the profitable re-use of waste deriving from the livestock productive chain through their active involvement in the testing phase, exchange visits, workshops and final seminar. - Livestock SMEs involved in the projectwill become innovation drivers for their respective territories, therefore CM will provide them with specific communication and dissemination materials to be shared with the other enterprises and SMEs.	- Social Media (facebook and twitter) - Project mobile application - Publication and presentations of projectportrait and project materials (flyers, brochures and videos) - Organisation of communication anddissemination events - Story telling of livestock farmersinvolved - Organisation of trainings, workshops,exchange visits - Set up of an Interactive support tool
Support public actors in the formulation of policies that recognize fertilizers deriving from livestock waste and incentive the adoption of innovations tested.	Public actors will be supported thanks to the following project outputs: - Output 4.2: The formulation of policies guidelines regarding livestock waste management and fertilizers production from this waste will permit to orient policy makers in the formulation of policies that stimulate and favour SMEs innovation adoption in this field (D 4.5.1). Furthermore, agreed regional road maps on actions to undertake for the drafting of national and European legislation favouring innovations in the field of livestock waste management (D 4.5.2) These outputs will contribute to the programme output indicator 1.1b	- Raise awareness amongst policy makersabout the economic and environmental benefits of the introduction of innovative technologies tested through the divulgation of the evaluation activities results. - Raise awareness of local, regional and national public authorities about the strengths and weaknesses of actual policies in their influencing effect on the adoption by SMEs of innovations for livestock waste management. - Advocate public actors on the strategicpolicies they can set up in order to incentive the adoption of innovations for livestock waste management through their direct involvement in the formulations of policy guidelines and organization of regional thematic round tables.	- Regional workshops, site tours, roundtables - Formulation and wide dissemination ofpolicy guidelines - Organisation of communication anddissemination events - Final international seminar

Improve transnational cooperation and connections between actors of the quadruple helix (research bodies, businesses, public authorities, civil society) and other stakeholders.	The transnational cooperation will be improved thanks to the following project outputs: - Output 4.1: Implementation of the knowledge and transfer plan (D 4.2.2.) This Specific Objective will be achieved also thanks to the Implementation of the activities related to the communication and dissemination plan (D.2.1.1).Networking activities will be carried out throughout the whole project in order to enhance cooperation between all involved stakeholders and share information and knowledge. Workshops, technical exchange visits, site-tours, seminar will be organized following a multi-stakeholder approach, permitting an active involvement of each actor. These outputs will contribute to the programme output indicator 1.1d.	- Improve knowledge and know-howexchange between actors of the quadruple helix (research bodies, businesses, public authorities, civil society) and other stakeholders, at local, national and international level - Improve dialog between actors involvedin livestock waste management at local, national and international level - Create experiences exchange among quadruple helix actors on field practices deriving from previous and current EU projects.	- Regional workshops - Exchange visits- Trainings - Site tours visits - Final international seminar

Programme output indicator	**Programme output indicator targets**	**Projet main output quantification**	**Project main output number**	**Project main output**
Number of operational instruments to favour innovation of SMEs	4	4	Work package4-1	4 innovative demonstration plants producing organic fertilisers (Struvite);
Number of enterprises receiving grants	1	1	Work package5-2	Policy guidelines
Number of enterprises receiving non-financial support	1	1	Work package4-2	Comparative analysis on the results achieved by the 4 case-studies including technical, agronomic, environmental and economic aspects
Number of transnational innovation clusters supported	1	1	Work package5-1	Report on the implementation of the knowledge transfer plan

2.2 C.2.2 Target groups

Target groups	Description	Target value
Sectoral agency	Regional agencies for rural development, environmental, energy and employment agencies will be mainly involved in the communication and transferring activities in order for them to capitalize project results.	4.00 Number
Other	With the category "Other" we refer mainly to the Project consortium and project partners	14.00 Number
Business support organisation	Business incubators, local chambers of commerce, and enterprises confederations, to be involved in the transferring activities.	8.00 Number
Education / training centre and school	Secondary schools (eg professional schools) are targeted by communication activities and the"site tours", in order to offer to students future employment opportunities	8.00 Number
Enterprise, except SME	Potentially interested big enterprises (as Fertilisers producers)	2.00 Number
General public	Citizens	100.00 Number
Interest groups including NGOs	Environmental associations, Local Action Groups (LAGs)	8.00 Number
Higher education and research	Research institutions and universities carrying out research on agriculture and livestock sector; engineering, agriculture, environmental sciences and economics faculties, etc.	4.00 Number
Infrastructure and (public) service provider	Waste collection companies	4.00 Number
International organisation, EEIG	International organizations dealing with environment (EEA, IPCC), agriculture and livestock (CGIAR, FAO) standardisation of fertilizers and technologies (ISO, IFA)	6.00 Number
Local public authority	Municipalities, district councils	16.00 Number
National public authority	Ministries of agriculture, environment, development, economics, and established national authorities dealing with policies on waste disposal and recycling, agriculture economic development, etc.	27.00 Number
SME	Livestock SMEs are the main users/beneficiaries of the project results. They will receive support to improve innovation capacities on waste management. Groupings of SMEs, including cooperatives/associations also constitute the project target groups	35.00 Number
Regional public authority	Representatives of regional authorities, e.g. regional council, innovation, agriculture, environment, waste management, sustainable development and economic departments, committee of the regions (CoR) members.	150.00 Number

3. C.3 Project context

3.1 C.3.1.a. How does the project contribute to wider strategies and policies?

RE-LIVE WASTE contributes to Europe 2020, addressing challenges related to R&D, innovation, energy and climate change. The project will play a role in the regions' transition to a greener, environmental friendly economy since the organic fertilizers that will be produced from the transformation of livestock waste are more efficient compared with energy-intensive mineral fertilizers, as they release very low GHG emission values throughout the production cycle. The small-scale pilot Struvite Precipitation (SP) plants (project output 1- pilot activity) will allow for the abatement of recovery of nitrogen alongside with phosphorous, allowing farmers to comply with the EU Nitrates Directive as well improving the "Nutrient Use Efficiency" of the farming activities, therefore contributing to safeguarding the environment and promoting green growth. RE-LIVE WASTE falls within the "macro regional" dimension since the project focuses on rural areas that represent important challenges due to their resources, development potential and the economic difficulties they are confronted to. The project will strengthen transnational and regional intervention strategies in waste management where transnational cooperation can contribute to improve regional and territorial practices. RE-LIVE WASTE also contributes to reach the objectives of the LIFE Programme
(2014-2020) concerning the shift towards a resource-efficient economy, reduced GHGs emissions, protection of the environment and supporting better environmental governance at all levels. The project is also in line with regional policies in the MED area that consider innovation adoption as the key driver for competitiveness and growth, in line with the Regional
Smart Specialization Strategies and contributing to the smart growth objectives of the Territorial Agenda 2020. RE-LIVE WASTE addresses environmental objectives of Agenda 2030, and contributes to the achievements of Sustainable Development Goals 6, 8, 9, 12, 13, 15.

3.2 C.3.1.b. If applicable, indicate if the project contributes to the following strategies and describe in what way

	-	-
If applicable, indicate if the project contributes to the following strategies and describe in what way.		
EU Strategy for the Adriatic-Ionian Region (EUSAIR)	.	RE-LIVE WASTE contributes to Pillar 3-Environmental Quality of the EUSAIR strategy. Through optimization of the management of livestock waste, rich in nutrients and pollutants, it will reduce waste, nutrients and pollutants flows to water bodies. Furthermore, the project activities of supporting SMEs in innovation adoption and networking and information sharing significantly contributes to the crosscutting issues of Capacity building and communication and Research and Innovation, and SMEs.
Alpine Space Strategy	.	RE-LIVE WASTE doesn't directly contribute to the Alpine Space strategy. However project results will be spread to the all EU and will benefit also the Alpine countries.

3.3 C.3.2 How does the project build on available knowledge?

RE-LIVE WASTE will build on the knowledge generated by EU projects that have dealt with the topic of integrated innovative solutions in livestock waste management and its recycling/reuse. For instance, Ferpode, Wavalue, Metabioresor and Livewaste produced interesting outcomes on which our project will capitalize. Regarding the later, RE-LIVE WASTE will upgrade the pilot plant installed in Animalia's (CY) premises for the production of Struvite, in order to operate also the N precipitation. In spite of the existing knowledge and experiences in the field, they are circumscribed to a limited number of regions and there is still a lack of common knowledge, instruments, policies and legal framework to stimulate the adoption of innovations in this field and the real commercialization possibilities of the end-products obtained from the recycling of livestock waste. RE-LIVE WASTE will fulfill this gap and will directly involve 4 regions in IT, CY, SP and FBH with the objective to disseminate and transfer the knowledge and know-how generated at multi-regional and multi-stakeholder levels thanks to far-reaching transfer strategy, thus improving transnational cooperation and connections between the quadruple helix actors both within and across regions. This will accelerate not only innovation adoption among livestock companies but also the need to implement a common suitable legal framework that will lead to the removal of barriers and to the establishment of a functioning market for organic fertilizers (i.e. a revision of the EU Nitrates Directive and the EU Fertilizers Directive would be necessary), contributing to the creation of new businesses and employment opportunities in the MED and EU regions.

3.4 C.3.3.a What are the synergies with past or current EU and other projects or initiatives the project makes use of?

RE-LIVE WASTE does not start from scratch but build on knowledge generated by other project initiatives, some of which have already been implemented by the partners. As a matter of fact, RE-LIVE WASTE re-uses a lot of information, directly generated by the partners or within other EU projects, thus avoiding the duplication of information and re-inventing the wheel. The use of existing knowledge as a starting point will place the project in an advantageous position, to go further. Consortium has already visualized the information regarding the state of the art in the production and management of livestock waste in Cyprus since the partner (CUT) has been involved in the project Livewaste. Likewise, the acquisition of information on the region of Murcia during proposal writing has been possible thanks to the Spanish partners IMIDA and ALIA that participated in Metabioresor (project that validated a pilot plant managing waste and by-products coming from the pig sector and transferred the results to the public and private sectors in 2 countries, developing country-specific approaches). During the project design, partners collected all 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. This permitted to identify the best innovative solution to be tested in the project. RE-LIVE WASTE will organize and summarize All this information will be of paramount importance since will be used as background knowledge and input in the implementation of the activities foreseen by the project in WP3 and WP4. In addition, the approaches followed in other initiatives to transfer, disseminate and communicate the results to public and private stakeholders, mappings of policy instruments, as well as the training materials developed, will be taken into account when carrying out the activities under WP3 and especially those under WP4.

4. C.4 Horizontal principles and evaluation

4.1 C.4.1 Please indicate which type of contribution to horizontal principles applies to the project, and justify the choice.

	Type of contribution	Description of the effect
Sustainable development	positive effects	Project directly focuses on reducing environmental impacts of livestock waste and increasing resources efficiency. Measures, such as the use of video conference to reduce travelling, publications on FSC-certified paper (double-sided copies), reduction of material consumption, use of recyclable and short supply chain products will be adopted in order to reduce the environmental impact of the project itself. Low-carbon emission travels will be preferred, according to local transport infrastructures. Green public procurements will be launched. Special attention will be paid to raising awareness of beneficiaries, stakeholders and the wider public on environmental and sustainability issues, through information and sensitisation actions.
Equal opportunities and non-discrimination	positive effects	The project will adopt the necessary information and communication measures in order to allow all different population groups to benefit from project activities and results. Transferring and information exchange activities will be open to the wider public and sensitisation will be carried out in order to involve the whole community in the implementation regions. Workshops, meetings, site-tours, final seminar logistics will consider the participation of people with disabilities, avoiding locations with architectural barriers, providing personal assistance and interpreters for deaf-mute people. Organisers will promote local attractions and amenities to benefit the local economy and valorise the cultural local heritage.
Equality between men and women	positive effects	Gender equality, gender equity, gender identity are respected and guaranteed. During project implementation several leverage points are addressed to promote gender equality: promoting equal employment opportunities, increasing organisational awareness on the importance of gender equality (e.g. during Steering Committee meetings), guaranteeing women's access to trainings, communication and dissemination activities, considering means to relieve possible constraints to women's mobility (transport time, child care). The project will seek to encourage women to enter in non-traditional professions, for example in "green" and innovative sectors. The project takes into considerations the suggestions of the Advisory Group on Women in Rural Areas.

4.2 C.4.2 Please indicate which type of evaluation is foreseen and justify the choice.

	-	Type of evaluation	Timeframe
Does the project foresee an evaluation?	Yes	mixed	on-going

Monitoring and evaluation will be realized at internal and external level. Internal quality evaluation will involve all partners through project meetings, self-assessments and feedback from involved stakeholders and will continuously assess performance and progress of implementation related to project objectives and indicators. The results of the on-going assessment will be presented and discussed during the Steering Committee meetings, in order to improve project realization and its impacts. An external expert will be recruited for external monitoring at the beginning of the project following the public procurement procedure provided by MED programme. The expert will support and monitor project realisation, assessing progresses, identifying difficulties and proposing solutions for a sound implementation. The expert will perform two evaluations (mid-term and final). All costs for monitoring and evaluation will be included in the project budget breakdown and supported by the project.

STATE OF THE ART REPORT - PD Butmir, Sarajevo

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TEL. +39-75-31556 /335 7029166 / 338 3738868

sereco@serecobiotest.it

www.serecobiotest.it

SERECO BIOTEST S.a.s.

Via C. BALBO,7

06121 PERUGIA

Project title and acronym	**RE-LIVE WASTE-** **Improving innovation capacities of private and public actors for sustainable and profitable REcycling of LIVEstock WASTE**
Work Package	**WP-3**
Activity n and title	**3.2 - Preliminary activity- preparing pilot activities**
Deliverable n. and title	**D322 - State of the art reports**
Responsible Partner	**Sereco Biotest**
Participating partners	**All partners**
DOCUMENT TITLE	**STATE OF THE ART REPORT** **BOSNIA** PD Butimir Sarajevo
Main authors	**Roberto Poletti** **Luca Poletti** **Alessandro Toccaceli** **Francesco Rinaldi**
Reviewers	**Luca Poletti** **Francesco Rinaldi**
Rev.	**05 FINAL / 19-02-20**

Description of case-study and geographic/cartographic framework

The testing plant will be installed at the "PD Butimir" farm located in Sarajevo (Bosnia&Herzegovina).
The zootechnical activity of the farm consists in cattle breeding. The farm hosts an average number of 830 cattle heads apportioned to different weight classes according to the following scheme (extracted from the returned questionnaire).

Case study:
Bosnia and Herzegovina
Site of the Project implementation: "PD Butmir", Sarajevo (dairy cows' farm)

Natural conditions in mainly part of Bosnia and Herzegovina (BA) are favorable for animal production. But less fraction of total animal products is market oriented. Reason for that is small farms serving more as a factor of social stability, particularly in the rural areas.
Currently, cattle production in Federation of Bosnia and Herzegovina (FBA[1]) is represented by approximately 214 000 heads, of which 160 000 are cows and heifers. Main problem is problem is fragmentation of farms (average agricultural land is less than 2 ha per farms) causing small number of animals kept on the farms: The land constraint is greatest for ruminant livestock, where the key to profitable production is forage production. In FBA dominate farms with less than 70 dairy cows, while only six farms keep more than 300 dairy cows. Mainly, farms numbered 1-10 cows accompanied by poor housing conditions and insufficient education of farmers in the application of new technical and technological knowledge. The largest farms in the FBA have 600 to 800 dairy cows and daily production of 12 510 kg milk.
Dairy cows mostly kept in *tie-stall* housing systems except a few bigger farms designated to free stalls with access to outdoor. Almost all farms in FBA faced with problem regarding to manure management due to improper storage, manure manipulation and as well as no existing evidence and insufficient official control of environment issues in general. Therefore animal production could have a negative impact on the environment (point and non-point pollution) with nutrients leaching from animal waste disposal sites or from the improper use of animal waste.
At state's level there are some restrictions and requirements for using manure and agrochemicals in protected zones along lakes, rivers and watercourses but nothing for vulnerable areas. Additionally, regulations regarding to fertilizers and other agrochemicals, their labelling and instructions to users are exist but only laid down in the primary legislation. Bosnia & Herzegovina has the primary legislation remarks about Good Agricultural Practice (GAP), but yet no clear description of GAP and lack of secondary legislation or other recommendations.

Farm "Butmir" is located in a suburb of Sarajevo, very close to human settlements. The farm housed about 950 heads of which are 500 dairy cows in tie-stall system. The farm has about 250 ha of arable land. Mayor crops growing at farm's land are lucerne (1400 t), maize for silage (6000 t) and grass-legume mixtures (200 t). Dairy cow manure at farm „Butmir" is collected, stored, and applied to crops in both liquid and solid form.

[1] Administrative part which accounts for about 51% of the total area of Bosnia and Herzegovina which is relevant in this case study.

Solid manure consisted of feces and beading material (chiefly chopped straw and small proportion of *wood* shavings) scraped from dirt-floored stalls and usually stockpiled outside in open basins made of concrete. Slurry (liquid excreta from stall and technical water deposited in lagoons. About 80% of total manure and total slurry were applied to farm's arable area 4-5 times per year. Production of manure is estimated at amount of 13000 t annually. In a scenario where 80% of the total amount of manure is applied on about 250 ha of arable land assuming that nitrogen content in manure is about 5 kg per ton the total amount of the applied nitrogen is more than 400 kg what is definitely about 2.5 times more than the Nitrate Directive regulation.

SPECIES 3 (CATTLE)			**Specify: milk, meat**			Milk			
			Average number of bred heads per year			502			
Categories (unit number)			**Weight class apportionment**						
			kg 150-300	**kg 300-600**		**Kg 50-150**	**Kg 150-300**	**Kg 300-500**	**kg > 600**
Average weight per category (Kg)									
						33	**90**	**205**	**502**
BREEDING SYSTEM			**In general: sedentary/wild** **for birds: ground/in battery,** **for cattle: couchette,litter, etc…**			**tie stall housing system with straw as bedding material**			

Milk cows amount to 502 animals

The main cultivation crops associated to the breeding activity are herewith listed.

CROP PRODUCTION		
SPECIES 1	**Corn, wheat, grain, barley, rye, etc.**	**Corn (silage)**
PRODUCTION[2](LAST YEAR)		**5.139 t**
CULTIVATION AREA (extension)	**in ha**	**170**
ESTIMATED PRODUCTIVITY	**in t/ha**	**30,23**
SPECIES 2	**Corn, wheat, grain, barley, rye, etc.**	**Lucerne**
PRODUCTION[3](LAST YEAR)		**415 t**
CULTIVATION AREA (extension)	**in ha**	**20**
ESTIMATED PRODUCTIVITY	**in t/ha**	**31,11**
SPECIES 3	**Corn, wheat, grain, barley, rye, etc.**	**Clover/grass mixtures**
PRODUCTION[4](LAST YEAR)		**314 t**
CULTIVATION AREA (extension)	**in ha**	**73**
ESTIMATED PRODUCTIVITY	**in t/ha**	**4,3**

The total cultivation area amounts to 263 Ha.

Silage corn, lucerne, and a mixture of clover and grassfarm are being cropped in the framework of a closed-cycle corn-based swine breeding with the raising of heavy pigs.

[2] Referred to the last year
[3] Referred to the last year
[4] Referred to the last year

Herewith following are reported in Fig.1 the geo-referenced image of the farm drawn by Google Earth and in Fig. 2 a schematic map with the localization of the farm operational units.

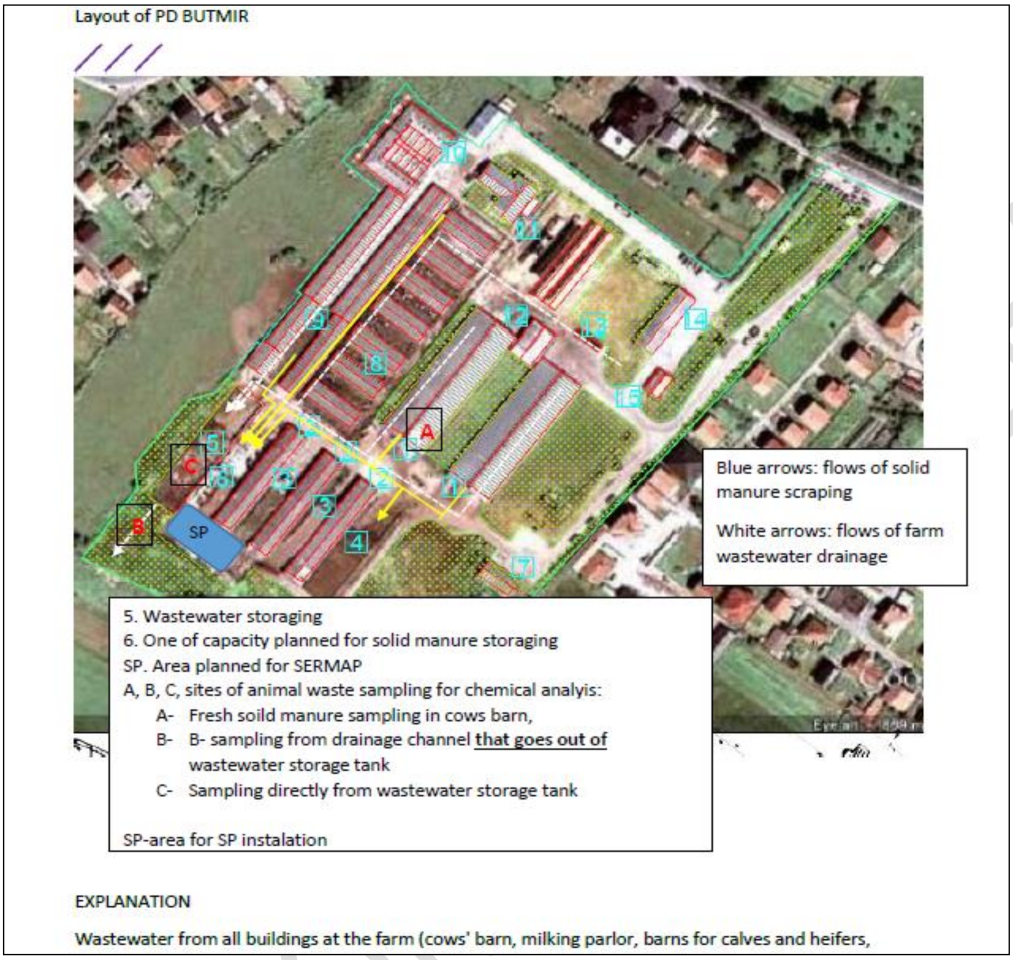


Fig 1: Geographic framework of Budimir with layout of major facilities

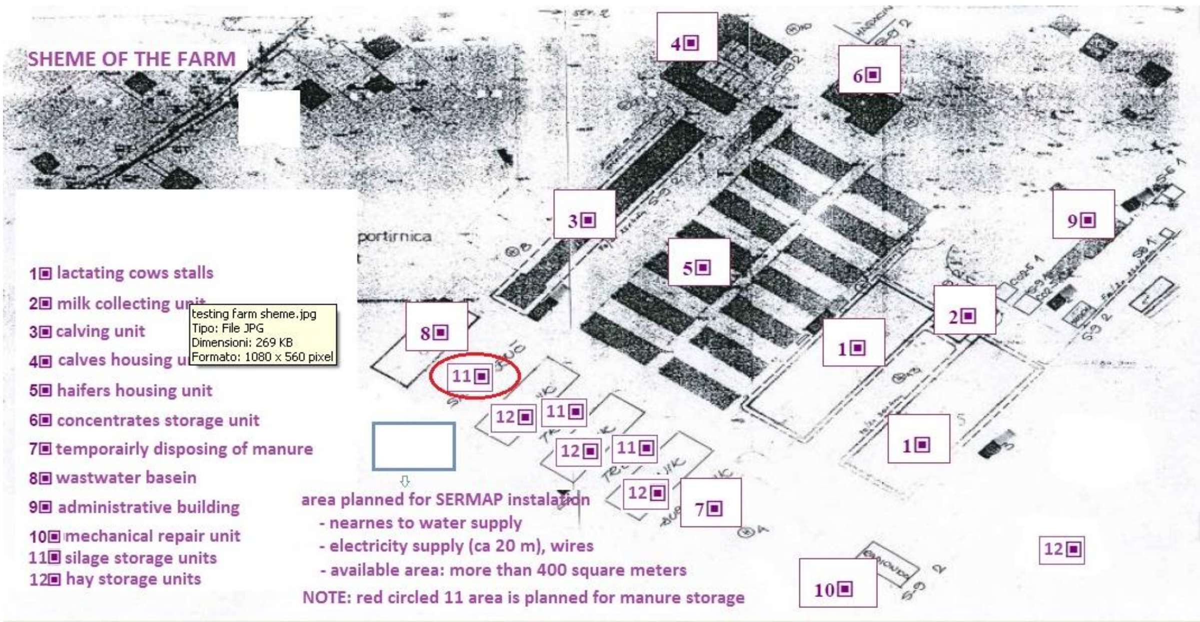


Fig. 2: Sketch map with the localization of farm operational units

Techno-economic analysis of waste management and charachterization of the matrices to be submitted to the SP process

The flow of high-entropic materials generated by the farming activity is twofold and consists in:

1. Solid manure
2. Wastewater (WW)

1. Solid manure

Solid manure produced in the stalls and animal housing (1, 2, 3, 4, 5 depicted in Fig.2) is scraped and moved away by means of tractors and subsequently concentrated in storage unit 7, 11 and 12 that are in reality conceived as silos for silage. Those silage tranches are used for manure storage only when they are empty, otherwise manure gets spread directly onto fields. There are 4-5 silage silos available of this kind in the livestock breeding facility. The yearly average manure production is **6550 t/year**. Therefore, the storage time availability for each silos, being each one **1600 m^3** in capacity, is approx. **4 months**. In the period between January and September the manure volume available for testing purposes will amount to approx **3200 m^3** (corresponding to 2 silage silos being fully available for manure storage), whereas in the period between September and December, there will be a lower amount of stored and available to SP due to the lack of silage capacity.

A typical composition of the manure produced "as is" is reported in Tab.1.

Tab .1 Chemical composition of manure (data provided by SERNA and University of Sarajevo)

PARAMETER	
TS %	15
Total N mg/l	3200
N-NH4 mg/l	200
PO4 mg/l	300
Ca mg/l	330
K mg/l	170
Mg mg/l	50

The solid content of the matrix is 15% but there could be fluctuations depending on the storage conditions that are heavily affected by the weather. For a large part of the year TS% could significantly rise thus determining a less favourable situation with regard to the treatability of the matrix for nutrient recovery through SP.

2. Wastewater (WW)

WW originates from all the farm buildings (cows barns, milking parlours, barns for calves and heifers, administrative facilities, mechanical service building, etc…). The WW flow encompasses also rainfall waters. The overall WW flow is channelled into a specially built underground storage tank with a capacity of about **4000 m^3**, whose level varies depending on the amount of WW produced as well on meteoric precipitations. The storage is provided with a surface sampling port from which WW is transferred into cisterns for fertigation (2-3 times over a one-year period depending on the amount of WW produced and on precipitations). From this storage WW is drained out to the nearby water channel through Channel B (see Fig.1).

The total daily wastewater production is about **60 m^3**. The daily amount of WW spread out onto the fields is approx. **30m^3**. In other words, **HRT** of the storage cistern is **2 days**.

Tab. 2 reports the typical chemical composition of such wastewaters.

Tab. 2 Chemical composition of wastewaters (data provided by SERNA and University of Sarajevo)

Paramter	unit	values		
		7/2018	8/2018	9/2018
pH		7,18	8,26	7,73
Total disolved solids (TDS)	mg/l	238	146	150
Total suspended solids (TSS)	ml/l	1,63	1,18	1,23
Total nitrogen (as N)	mg/l	108,01	212	15,51
Ammonia (as N)	mg/l	98,9	202	12,3
Total phosphorus (as P)	mg/l	0,32	0,34	0,36

Results of wastewater analysis- PD Butmir, B&H, point B at the Layout (nevember 2018)

Site: wastewater storage tank at 1.0 m in depth

Paramter	unit	values
Ammonia (as N)	mg/l	460
	mg/l	530
	mg/l	360

The chemical composition of the wastewater has been made by drawing the sample a) at a sampling point (point B according to the layout of Fig.1) located downflow the wastewater basin located throughout the drainage channel that leads the WW to a surface watercourse discharge point (see Picture 3, see ANNNEX 1). The analysis has been repeated in 3 different times b) at a sampling point corresponding to the WW storage tank (point C of the layout of Fig.1) at 1m in depth (see Picture 2 see ANNNEX 1).. At point B, 7 parameters have been analyzed, while at point C only ammonium (as N) has been determined.

Requirement analysis (pollutant removal request)

B&H has adopted an array of environmental regulations inspired by laws already being enforced among the EC state members including environmental acts on water protection and waste management. In addition to that, although Bosnia does not have a well-established set of regulations or recommendations for the storage of slurry and manure, environmental protection requirements, addressed to curbing water pollution, including the protection of groundwaters, are presently in force.

It appears evident that the wastewater drainage system present now at the PD Butimir farm does suffer limitations in ensuring the highest degree of water protection due to the absence of a WW treatment plant at the point of discharge as well as an irrational network for sewage collection.

Despite that, it must be noticed that the level of the parameters considered in the WW does not seem to be particularly critical. Only for N-NH_4 we can observe a concentration exceeding the legal threshold set by the EC standard which equal to 30 mg/l N-NH_4 for the discharge into surface waters and only in 2 samples out of 3. Moreover, the concentration of NH_4, although exceeding the limit, is still within the range allowing the treatment with a conventional biological active sludge treatment plant (es: NITRO-DENITRO, ANAMMOX, etc…). In other words, we are not in the presence of a hyperazotated matrix and then the implementation of the novel SP technology to this case would not entirely meet the scope of the project.

Along with that, the real concerns of the farmer in terms of environmental management and environmental risk perception should be taken into due account.

Local farmers report that the management of manure is by far the main issue not only for the storage, that is now operated by resorting to tranches used for silage, but also for the air pollution and the olfactory disturbance exerted on the surrounding settlements by the storage of fresh manure.

For all that and with the aim at improving and modernizing the overall management of the farming organization, it looks more appealing to tackle the manure issue with a view to making a few steps forward in the amelioration of it under different standpoints (operational, environmental, agronomical).

Waste management strategy

The strategy envisaged is directed towards the improvement of the handling of solid manure by resorting to solid-liquid separation (centrifugation) and subsequent valorisation of the solid part of it whilst allowing a better treatability of the resulting liquid phase (centrate) by means of SP. In this way the following goals would be achieved:

1. Reduction of the space required for manure handling and storage
2. Reduction of olfactory nuisance and air pollution
3. Recovery of solid materials as solid sludge bearing agronomic value
4. Easy of transport and distribution onto fields of a more concentrated and stabilized sludge than the "as is"
5. Facilitation in manure treatment by means of SP as the high level of solids (> 15%) would impair the reaction. Indeed, the dewatering process would produce a centrate with a significantly lower solid content (< 8% expected) thus permitting the establishment of more favourable conditions for the SP reaction to be successfully carried out.

Daily flow-rate treatment and storage verification
Hypothesis on dewatering separation efficiency

As it was not possible to carry out preliminary centrifugation lab tests due to the severe constraints in force for the shipping of manure sample and animal by-products from Bosnia to Italy, hypotheses were based on technical literature and the on-field experience of one of the leader company in the field of dedicated technologies for processing livestock slurry.

The min-max separation efficiencies that can be envisaged are reported in Table 3.

Tab.3 Separation efficiencies hypothesized based on literature and practical industrial on-field experiences

ST(%)	N tot (%)	P_2O_5 (%)	Metal Bivalent Cations (%)
27,6-77,8	10,4-36,5	32,8-73,7	1,5-38,5

Accordingly, the expected levels of the chemical key chemical parameters to be expected in the liquid fraction of the Budmir cattle manure outgoing the centrifugation process and thus to be submitted to SP are listed in Tab.4.

For $N\text{-}NH_4$ and PO_4 the same separation coefficient as total N and P_2O_5 have been assumed. For earth-alkaline cations an average of the separation coefficients expressed for bivalent metals has been considered.

Tab.4 Expected levels of the chemical key parameters in the centrate

Parametres	Min	Max	Assumption for calculation (mid-point)
TS (%)	3,33	10,86	7,10
Total N mg/l	2032	2867	2450
$N\text{-}NH_4$ mg/l	127	180	154
PO_4 mg/l	78,9	202	140
Mg mg/l	44,5	30,5	37,5
Ca mg/l	201	294	248
K mg/l	152	104	128

Hypothesis on nutrient abatement and recovery through SP

On the ground of the hypothesized dewatering efficiency, the expected total solids and concentrations of nutrients and cations relevant to the SP reaction in the centrate are recapped in Tab. 5 as well as the data concerning:

- flow rates of the nitrogen loads liable to be fertigated
- land availability
- hypothesized $N\text{-}NH_4$ abatement
- expected production of Struvite/O-SEP (Organic-Struvite Enriched Precipitate) according to past Sereco's testing experiences.

The agricultural surface being subjected to fertigation at Butimir is 73 Ha according to the returned questionnaire (see ANNEX 2). All the available surface must be considered as entirely vulnerable…"

Tab. 5 Expected total solids (TS) and concentrations of nutrients and cations relevant to the SP reaction in the centrate

1. CHEMICAL COMPOSITION MANURE "as is"										
		Kg/m³	**SE % MIN**	**SE % MAX**	**SE % AVG**	**C Kg/m³ MIN**	**C Kg/m³ MAX**	**C Kg/m³ AVG**		
TS %	15		27,6	77,8	52,7					
Total N mg/l	3200	3,2	10,4	36,5	23,5	3	2,03	2,45		
$N\text{-}NH_4$ mg/l	200	0,2	10,4	36,5	23,5	0	0,13	0,15		
PO4 mg/l	300	0,3	32,8	73,7	53,3	0	0,19	0,23		
Ca mg/l	330	0,33	10,5	38,5	24,5	0	0,21	0,25		
K mg/l	170	0,17	10,5	38,5	24,5	0	0,11	0,13		
Mg mg/l	50	0,05	10,5	38,5	24,5	0	0,03	0,04		
2. HYDRAULIC AND SOLIDS FLOW-RATES										
Qtot t/y	6550									
TS t/y	983									
CS_SLU t/y	518									
TSslu%	0,25	**Hypothesized**								
TSslu t/y	129									
SLU t/y	2071									
LIQ aft DEW t/y	4479									
3. NUTRIENT LOADS FOR FERTIGATION										
	Kg/y		**Kg/y**		**Kg/y**			**Kg/y**		**Kg/y**
Total N as is	20960	**Total N sludge**	4915	**N- NH_4 sludge**	294	**%N-ORG sludge**	**N-ORG sludge**	4608	**Total N sludge**	4902
N- NH_4 as is	1310	**$N\text{-}NH_4$ lost centr**	13,10	**N- NH_4 centrate**	1003	93,75	**N-ORG centrate**	15042	**Total N centrate**	16045
TOTAL N -ORG	19650									

4. LAND AVAILABILITY										
	Ha		**Kg**		**Kg**		**Ha**			
Fert land	73	**Max N load**	12410	**Extra N**	8550	**Extra land**	50			
				Extra N-NH_4	3635	**Extra land**	21			
5. N ABATEMENT RATES										
N-NH4 SP ABATEMENT		**N TOT DEW ABATEMENT**								
	Kg/y		**Kg/y**		**Kg/y**					
90%										
SEP-retained N-NH_4	903	**Sludge-retained Tot N**	4902	**SludgeTot N +SEP retained N-NH_4**	5805					
Effluent N-NH_4	100									
6. LAND SAVINGS										
SPLand saving	5,3	DEW Land saving	28,8	**SP+DEW Land saving**	**34,1**					
7. SEP PRODUCTION										
	Kg/Kg N-NH_4									
Specific O-SEP production	17									
O-SEP obtained	15343									

LEGEND
SE = Separation Efficiency
Qtot = total yearly manure production “as is”
TS = total solids in manure “as is”
CS_SLU = Captured solids in slurry after dewatering
TSslu% = Total solids in % in dewatered slurry
TSslu = Total solids in mass in dewatered slurry
SLU = Slurry produced after dewatering
LIQ aft DEW = Total liquid flow rate after dewatering
Note: all the N calculations was based on the average SE and C values

A striking outcome of the simulation of Tab. 5 is that dewatering provides real benefits to manure management.

As much as 2071 t/y of slurry are produced thus about 1/3 of the total manure in-flow mass “as is”, being undoubtedly much easier to be handled and exported outside the farm boundary bringing about environmental and economic advantages.

As long as the nitrogen mass balance is concerned we can observe that a significant amount of total N splits into the solid sludge, 4902 Kg out of 20960 Kg of total N manure per year (about 23%).

As a consequence, as much as 29 Ha are saved in terms of fertigation requirement (the farm would need of an overall 123 Ha to bring all the nitrogen to fields according to the Nitrates Directive, with 73 Ha already being in the availability of the farm) because the N retained in the Centrifuged Sludge (CS) could be exported outside the farm boundaries and even sold as a fertilizer. The current market price in Italy for this kind of recovered of product is around 20 €/ton. The revenues for the selling of CD will then yearly amount to approx. 40k€. The CAPEX for the acquisition of the centrifuge would then be paid-back in less than 2 years.

When it comes to the positive effects of SP on the N abatement it can be said that by attempting a 90% removal rate of N-NH_4 [5]on the centrate centrifuge outflow the savings in terms of less agricultural surface to be devoted to fertigation is about 5Ha that, by summing up to the savings provided by dewatering, amounts to an overall 34 Ha. So, the combined action of dewatering and SP provides the farm with a 68% land saving with respect to the extra land required (34 Ha saved out of 50 Ha of extra land required).

In addition, SP set a 90% N-NH4 abatement rate gives a remarkable production of O-SEP of around 15,34ton/y. The revenues for the selling of it according to the current scientifical literature ranges from a minimum of 767€ to a maximum of 4600€ per year[6].

Definite and conclusive considerations will be drawn only after the completion of the testing trials and of a comprehensive techno-economic evaluation.

<u>Giving all that, the work plan here proposed encompasses the verification of the above-mentioned scenario of nitrogen removal and the subsequent recovery and valorisation of it as STRU/O-SEP, along with other nutrients and organic matter.</u>

The experimentation will necessarily include the appraisal of the hypotheses made about dewatering efficiency along with further investigating the composition of manure.

It is now worthy to make a few remarks as to how the expected composition of the centrate coming out of the centrifugation treatment can affect the outcome and the yields of the SP reaction.

Table 6 shows the calculations required to establish what amount of chemicals must be added for triggering the SP reaction.

[5] It must be recalled that SP only tackles N-NH_4

[6] Hypotesized selling price ranging between 50 and 300 €/ton

Tab.6 Calculations needed to establish the addition of chemicals for the SP reaction

ACTUAL VALUES					
Ionic species	**MW**	**C (mg/l)**	**MC (mn/l)**	**As element**	**MC (mn/l)**
NH4	18	154	8,6	**N**	6,6
PO4	96	140	1,5	**P**	6,8
Mg	24	37,6	1,6		
Ca	40	248	6,2		
K	39	128	3,3		

	MR ADJUSTMENTS*		
	NH4	**PO4**	**Mg**
MC	8,6	1,5	1,6
MR_act	1,0	0,17	0,18
MR_adj	1	1	1
MC_adj (mn/l)	8,6	8,6	8,6

* with reference to the most concentrated species

LEGEND
MW : molecular Weight
C = concentration
C_adj = adjusted concentration
MC = molar concentration
MC_adj = adjusted molar concentration
MR_act = actual molar ratio
MR_adj = adjusted molar ratio

What firstly results is that among the three ionic actors of the SP reaction NH_4 is the most relevant in terms of Molar Concentration (MC), with PO_4 showing a comparable MC with respect to Mg. In other words, Mg and PO_4 are equimolar.

Therefore, the RM NH_4:PO_4:Mg is as follows:

8,6:1,5:1,6

If we hypothesize to set the typical operative MR of 1:1:1 the final concentrations of the reagents to be added is the one reported in Tab. 7

Tab.7 Final concentrations of the reagents to be added in the SP reaction at an equimolar NH_4:PO_4:Mg ratio

	C_adj (mg/l)	Delta_adj (mg/l)
NH4	154	0
PO4	821	681
Mg	205	168

where $Delta_{adj}$ represents the increment in concentration that has to be assured in order for the reaction slurry to reach C_{adj}.

That means that for an hypothesized treating volume of $5m^3$ the quantity of reagents (in Kg) to be added is that indicated in Tab.8

Tab.8 Quantity of reagents to be added

V_treat (m^3)		Q_chem_in (Kg)
5	**NH_4**	0,000
	PO_4	3,407
	Mg	0,839

Based from these figures, the actual quantities of grade reagents to be introduced into the reaction tank have to be calculated .

By using an MR of 1:1:1, the daily request of reagents for the treatment of $5m^3$ per day based on Sereco's past experiences[7] is:

H_3PO_4 (75%): 4,68 Kg

$MgCl_2$ (47%): 8,76Kg

The presumable expected quantity of STRU/O-SEP[8] daily obtainable can be summarized as follows:

[7] On entirely different treatment media and thus to be confirmed experimentally
[8] "as is" in the form of slurry

DAILY FLOW	N abatement (%)
5 m^3	90
	O-SEP (Kg/d)
	10,4

By considering that the overall declared N quantity necessary to carry out the agronomic trials is 6Kg and by hypothesizing a presumable content of N% in precipitate of 3,6% [9], the operational time of the SP plan will approx. be 17 days (with a 90% N-NH_4 abatement on a 5 m^3/day flow rate treatment).

It must be taken into account that the final operational conditions, especially for the MR that is for the quantities of reagents to be introduced, cannot be ultimately established until the preliminary exploration/orientation testing trials (EOTT) are completed. EOTT might last several days. For this, it would advisable to treat a lower volume during EOTT in order to save on reagents and then operate at 5 m^3/days with a 90% N-NH_4 removal performance aiming at rapidly reaching the target quantity of STRU/O-SEP.

Hopefully, EOTT should give valuable indications leading towards streamlined operative conditions in terms of cost-effectiveness. Therefore, the depicted scenario with a RM of 1:1:1 has to be considered as a worst-case as it will be strived to operate SP with lower RM with respect to NH4 (e.g. 1:0.8:0.8, 1:0.6:0.6 etc…)

Moreover, time has to be devoted to the drying O-SEP before it gets ready for agronomic testing.

Therefore, with a supposed daily treatment flow rate of 5m^3/d and a 90% N-NH_4 abatement rate the reagent quantities to be used in the fully operation running of the SP plant liable to last 17 days will approximately be as follows:

H_3PO_4 (75%): 79,56 Kg

$MgCl_2$ (47%): 148,92 Kg

In Tab.9 the Ca/Mg and Ca/PO_4 ratios are reported.

Tab.9 Ca/Mg and Ca/PO_4 ratios

		Hindering	Inhibiting	Satisfactory
Ca+2/Mg+2	**4,0**	**0,2**	**0,5-1**	**1,13-1,45**
Ca+2/PO4-3	**4,3**	**1**		

According to literature, Ca strongly competes with Mg in the formation of struvite crystals and values of Ca/Mg ratio > 0,2 can hinder or inhibit the process. According to other literature sources though a Ca/Mg level ranging between 1,13 and 1,45 can still be regarded as satisfactory. In one case or the other, we are dealing with a very high Ca/Mg level (4.0) and thus particular attention must be paid to possible inhibiting effects induced by Ca. By the way, also the Ca/PO_4 ratio far exceeds the optimal level according to literature.

Despite all that, our experience suggests that these chemical indicators do not necessarily assume predictive value, due to the high level of complexity of the medium and the reaction mechanisms involved and thus the outcomes and yields of the SP must be evaluated experimentally case-by-case.

[9] Based on Sereco's past experiences and thus on entirely different circumstances that will have to be confirmed experimentally

Furthermore, it must not to be neglected the economic and agronomic value of other co-crystallization Ca-based species (like HAP) that might be liable to form along with struvite and/or O-SEP.

Conclusions

It can be envisaged that the entire action herewith proposed figures out as a valuable means to put the Butmir farm on the right way to significantly modernize its agronomic practices and contributing to close the gap with european standards as regards the management of livestock-derived farming wastes. Indeed, not only the bulk reduction will ease the handling and storage of manure, but also the recovery of solid materials with a significant agronomic value, both from the dewatering phase (as a sludge), and from crystallization (as struvite or O-SEP), will turn out to be a shining opportunity for the farmers to extraction value along the entire production chain. This will undoubtedly represents for the Butmir farm a first step leading towards a more comprehensive environmental reclamation action and a also prelude to the rationalization of the WW drainage system

Preliminary project
Introduction

Given the conclusions outlined in the previous sections, in the engineering strategy proposed the pivotal role is played by a dewatering treatment device that will ensure the SP process to be carried out in an appropriate medium having a ST content lower than 7-8%.

As stated previously, dewatering will give a much easier-to-handle solid material and at the same time an optimal centrate to be directed to the SP. Moreover, a substantial N fraction will be captured by the centrifuged sludge. This will significantly contribute to the recover and valorization of N as well to the reduction of the land requirement for fertigation. This latter will be made up of several sequential steps: pre-treatment (homogenization and stripping), reaction, sedimentation/separation, struvite/O-SEP drying and storage of the SP ammonium-depleted liquid fraction .

Since the installation of the dewatering plant will seemingly absorb a significant amount of the available budget, in this case the choice has been made to carry out the SP reaction without recurring to complex and technologically advanced crystallization units, with the aim of attempting the formation of struvite through the typical sequence of crystallization events (nucleation, crystal growth and agglomeration) directly on a tank volume reactor. A subsequent simple truncated-cone cylindrical settler will provide not only the separation of STRU/O-SEP from the liquid phase but also a possible additional contribution to the improvement of the SP yield from both a quantitative and a qualitative standpoint.

It is considered that, in order to meet the scope of the testing activity in Butimir, the SP reaction will be conducted in batch mode with a volumetric treatment rate ranging from 1 m^3 to max 5 m^3. Batch mode is deemed to be the elective option for crystallization processes to be made for small production rates, i.e. < 5kton per year. (A.Lewis et al. Industrial Crystallization Cambridge University Press 2015, pag. 211).

For all that, it could be assumed that the strategy here outlined is fully consistent with the scope of the Re-LIVE cooperation project which is focused to the exchange of knowledge and experiences and the implementation of custom-made solutions for the resolution of territorial problems.

Moreover, we consider of the utmost scientifical interest the testing of a particular “basic”, low-cost configuration of the SP plant like the one proposed here for Butimir, because a favourable and positive outcome would consolidate the effectiveness of this kind of process and demonstrate its flexibility and adaptability to a wide range of cases, including those characterized by a lack of economic resources including as well as the specific cases in which reutilization/readaptation of already-existing facilities has to be pursued.

Location of the pilot plant

The pilot plant for the treatment of manure and recovery of nutrients as SEP will be made at the PD Butmir livestock breeding facility in the Sarajevo district in Bosnia-Herzegovina

In Fig. 3 a 1:200 layout of the breeding farm is reported in which the area hosting the plant (SP) is highlighted

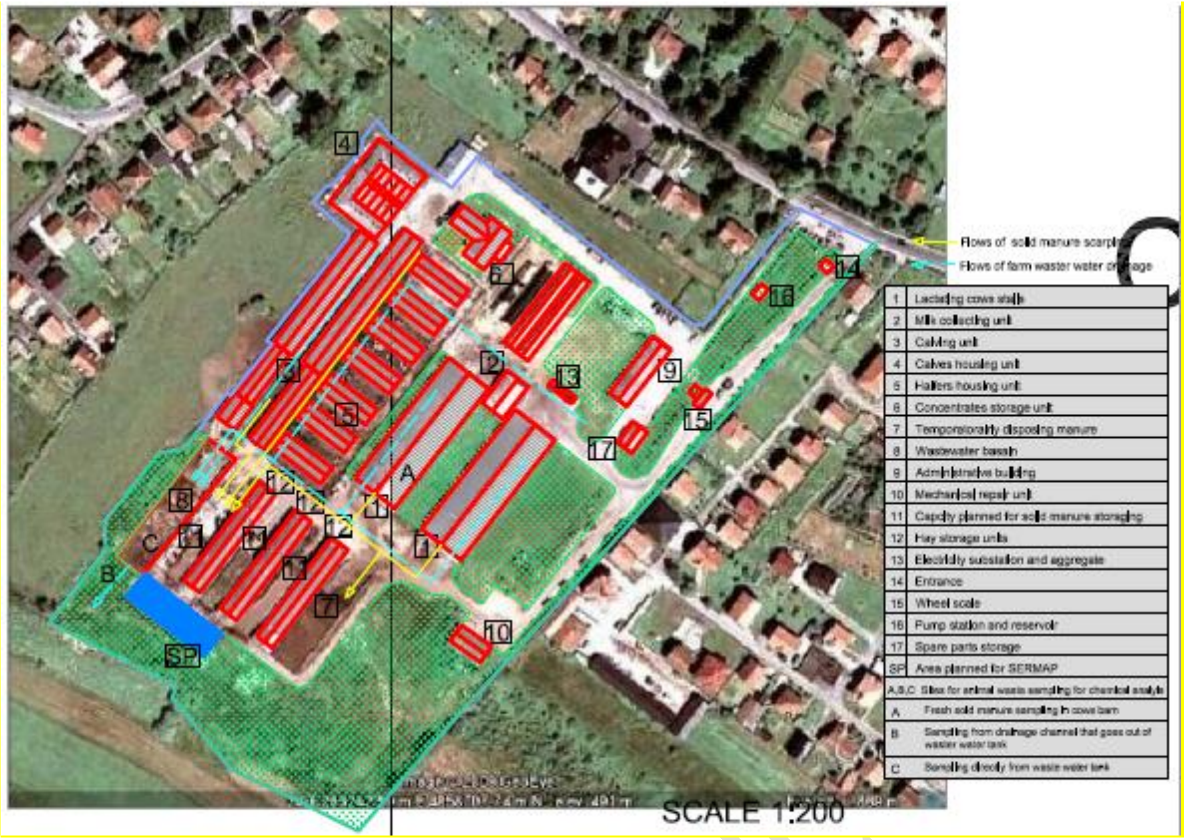


Fig.3 Location of the plant

Functional organization of the plant

The pilot plant will be made up of 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 will be 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
- Temporary storage of clarified medium and loading to the WW storage basin already present at the farm. The final storage of the SP treated effluent has been conceived to occur in the storage basin for WW for the only purpose of cost-effectiveness, but it is far from being an ideal solution. As a matter of fact the SP

treated medium actually suitable for fertigation would be mixed with WW that is not permitted to be fertigated but only discharged as en effluent only as long as strict limits on concentration pollutants are met. Therefore SP effluent should ideally be stored in a dedicated volume with the most appropriate solution being a lagoon, as the required storage capacity requested by the EC regulations must be equal to a 5-month time effluent production, in this case the volume being 1866 m^3. The realization of a an ideal fully-complying plant scheme should then necessarily encompass the set up of a dedicated storage volume (a lagoon) for the SP effluent destined to field fertigation.

The confirmation of the technical solution here described will depend on whether the costs incurred for the testing plant construction will comply with the project budget available for the partner

Herewith follows a dimensional and functional description of the process units used with indication of the performance characteristics of the electro-mechanical units.

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 tank has the following external dimensions:

Width 2.46 m;

Length 12.70 m;

Height 2.50 m

The volume was calculated to receive 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 12% of ST. The dilution, during plant start-up, will be carried out with source water, while, once the separation system will be fully operational, the centrate coming from the centrifuge will be sent back to the tank. Minimum and maximum level probes will control both the centrifuge loading pump and the pump installed in the centrifuge that operates the back-feeding dilution.

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 between 5 and 50 m^3 / h;
- Rated engine power of about 4 kW and 33 rpm;
- Size of sieve holes between 0.25 and 1 mm.

The separator must be mounted on a canopy supported by a pillar with a height of 4 m so to allow the discharge of the solid fraction in a concrete slab.

The unit 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.

Solid storage unit and liquid storage after separation

For the storage of the solid fraction a concrete slab to be placed below the canopy is provided having dimensions of m 4 x m 3. The slab will be slightly inclined to facilitate drainage.

For the storage of the centrifuged liquid a rectangular reinforced concrete tank will be provided with characteristics and dimensions identical to the loading/homogenization tank:

- Width: 2.46 m;
- Length:12.70 m;
- Height: 2.50 m.

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

An horizontal chpper pump connected having an estimated power of about 3 kW operates the transfer of the centrifuged liquid to the loading and homogenization tank assuring a flow rate of 4-5 m^3 / h.

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

As previously written, the centrate loading tank is separated in two compartments 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 by means of a 250 cm long DN100 PE pipe fixed with joists at the settler's walls and 25 cm higher with respect to outer wall of the cylinder's roof. 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 inner top section of the settler is provided with a toothed series. Externally to the toothed series a circular channel is provided having a width of 15 cm and a height of 15 cm with a slope of 3 ° with respect to the outlet pipe. The structure is raised 1,5 m from groundlevel.

The plating is made of stainless steel AISI 304 and is provided at its lower position with a connection for the placement of a draining bag.

The SP treated effluent is discharged by gravity, through a pipe in black PE DN50, into a small tank of 10 cubic meters of geometric volume in which ammonium sensors will be placed. The effluent will reach by gravity the WW accumulation basin already present in the farm.

SEP dehydration system

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

Reagent dosage unit

The reagents necessary for the SP reaction will be stored in small tanks (cisternette) which are generally provided by the supplier of the chemicals.

The cisternettes will be placed under a shelter upon a concrete slab. The dosing station will have a floor space of approximately 30 m^2 (m 6 x m 5).

The reagents that will be used in the process will be:

- Phosphoric acid (H_3PO_4), 75% degree of minimum purity;
- Magnesium chloride ($MgCl_2$) from 43% to 99% degree of purity;
- Sodium hydroxide (NaOH), 50% degree of minimum 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. Flow rate will range between 5 and 45 l / min. In addition, a connection for a 7/10 mm PE pipe and a single ball valve suitable for high viscosity liquids will be provided.

Control and monitoring

The following units will be provided:

1. Minimum and maximum level probes in the loading tank;

2. Electromagnetic flow meters for the hydraulic line operating the loading to the centrifuge and the settler;

3. pH sensors installed in the tank connected to the settler for loading and in the SP-treated effluent storage tank

4. Ammonium sensors in the loading tank to the settler and in the effluent storage tank. Measurement field: 0.1-2000 mg/l N-NH_4.

Control room, control and electrical wiring

The command and control panels will be installed inside a pre-fabricated box having dimensions of 3 m x 4 m or in another room already present and used for similar purposes at the farm. The technical characteristics of the switchgear and the mode of data transmission will be defined after completion of the project plant and receipt of a plan / diagram of the electrical system already present in the farm.

Piping

The dimensions, the materials and the interception devices are reported in the attached P & I.

The lengths and the arrangement of the pipes, the relative connections and the curvatures will be given along with the final detailed design.

Annexes

ANN 1 PICTURES OF FARM FACILITIES

ANN 2 RETURNED QUESTIONNAIRE

Technical outputs

TO1 FUNCTIONAL FLOW DIAGRAM OF THE PROCESS

TO2 HYDRAULIC DIAGRAM AND SIDE VIEW PILOT PLANT SECTIONS

TO3 SETTLER DESIGN

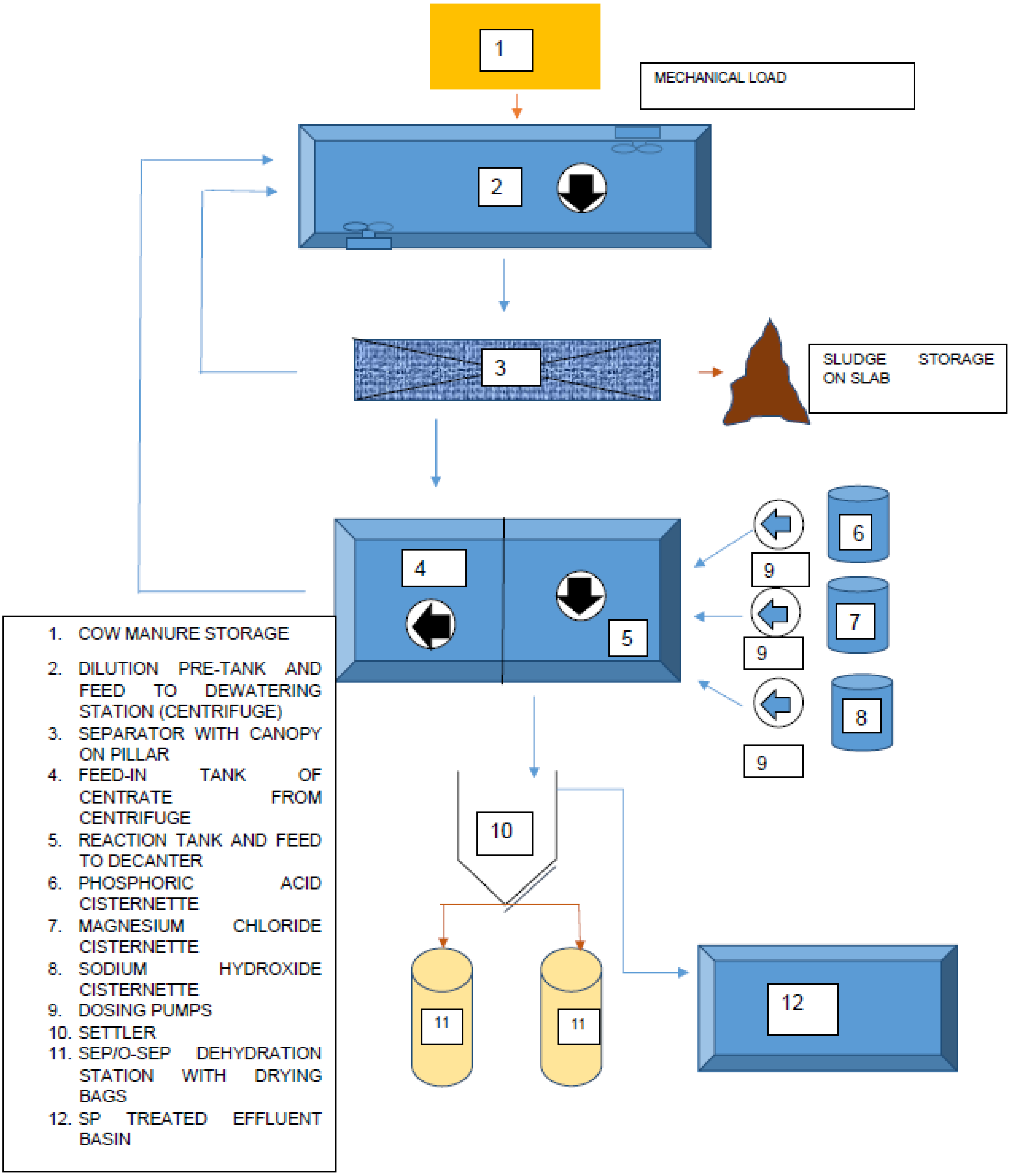
TO4 PILOT PLANT LAYOUT

TO5 PLANT ENERGY DEMAND

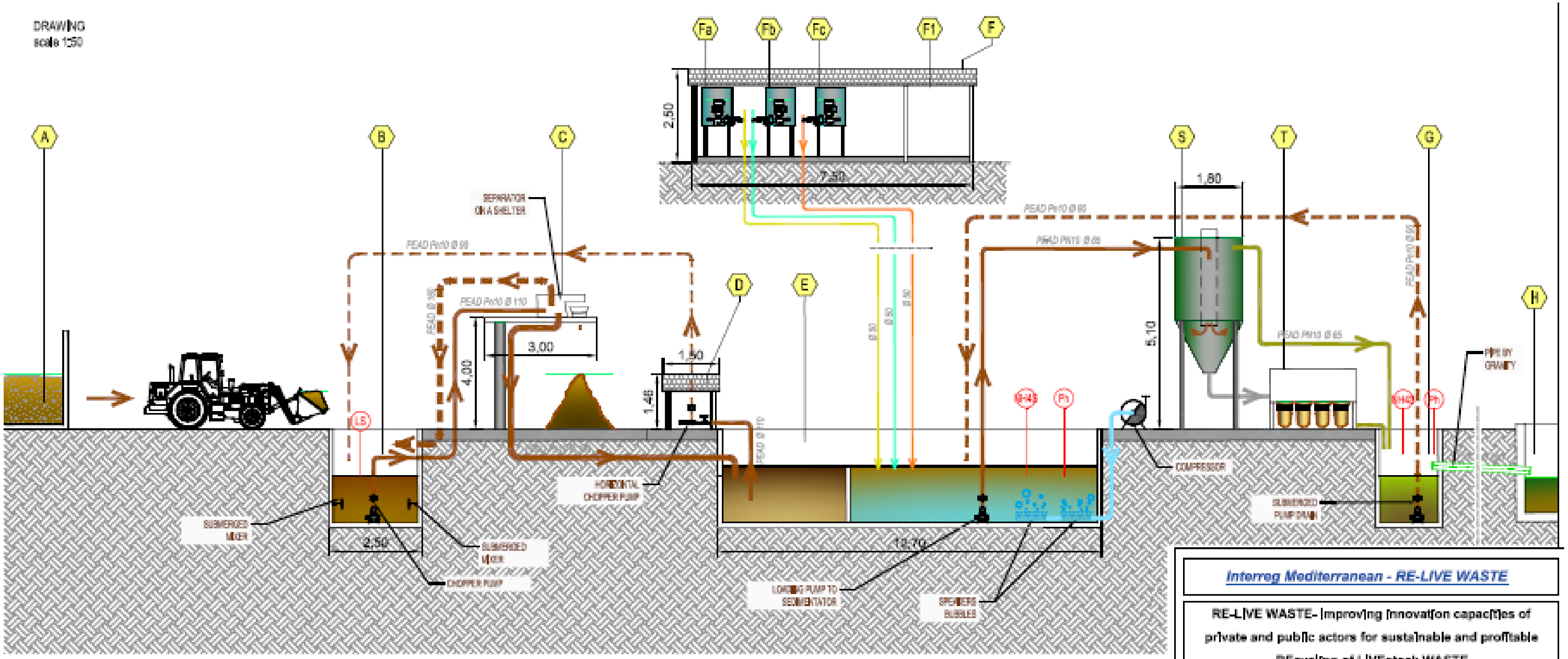
T06 ESTIMATIVE METRIC COMPUTATION

DIAGRAM FLOW SCP

(STRUVITE CRYSTALLIZATION PLANT)



1. COW MANURE STORAGE
2. DILUTION PRE-TANK AND FEED TO DEWATERING STATION (CENTRIFUGE)
3. SEPARATOR WITH CANOPY ON PILLAR
4. FEED-IN TANK OF CENTRATE FROM CENTRIFUGE
5. REACTION TANK AND FEED TO DECANTER
6. PHOSPHORIC ACID CISTERNETTE
7. MAGNESIUM CHLORIDE CISTERNETTE
8. SODIUM HYDROXIDE CISTERNETTE
9. DOSING PUMPS
10. SETTLER
11. SEP/O-SEP DEHYDRATION STATION WITH DRYING BAGS
12. SP TREATED EFFLUENT BASIN



COMPONENTS DETAILS

A — STORAGE SILOS of bovine manure: pick-up and transport to it with a work vehicle

B — PRE-TANK DILUTION AND LOADING TO SEPARATOR V = 66 mc; prefabricated underground structure; Tank dimensions m 12,70 x 2,50 x h 2,50
tank equipped with:
- SUBMERSIBLE MIXERS - 11 KW - S 2158 N - Q 3877 m3 /h
- 7,5 KW CHOPPER PUMP - Q 10-45 l / s - H 14,4-3 m

C — SEPARATOR ON SHELVES IN STEEL
overall dimensions m 3,00 + 0,80 (roof access board) x w m 1,70;
h from the ground m 3,00; coverage provided with parapet and step irons
SEPARATOR 4 KW THREE PHASE

D — HORIZONTAL CHOPPER PUMP HOUSING MANUFACTURER:
overall dimensions in plan m 1,50 x 0,80 m x h m 1,50;
- HORIZONTAL CHOPPER PUMP 3 KW - Q 10-35 l / s - H 11-3 m

E — SEPARATE LIQUID STORAGE TANK:
prefabricated underground structure; Tank dimensions m 10,20 x 2,50 x h 2,50
separate in two chambers:
- E1: SEPARATE LIQUID STORAGE TANK (58 cubic meters)
- E2: PRE-REACTION TANK AND SEDIMENTER LOAD (5 mc)
tank sector EQUIPPED WITH SUBMERGED
SINGLE CHANNEL PUMP FOR LOADING TO SEDIMENTATOR 1,6KW

F — DOSAGE STATION REAGENTS WITH DOSING PUMPS (FOR PHOSPHORIC ACID, MAGNESIUM CHLORIDE, SODIUM HYDROXIDE); dimensions l m 7,50 x w 1,50 x h 2,50m; cylindrical cisterns Ø0,80m and h m 1,80

Fa — CISTERN H3PO4

Fb — CISTERN MgCl2

Fc — CISTERN NaOH

F1 — Local COMMAND AND CONTROL PANELS

S — SEDIMENTATOR FOR ORGANIC STRUVITE PRECIPITATION

T — DEWATERING STATION OF THE PRECIPITATE WITH FILTER BAGS

G — CLARIFIED ARRIVAL TANK AND SAMPLE COLLECTION, V = 10 cubic meters
prefabricated underground structure, external dimensions l 5,00 x w 1,80 x h 2,50 m

H — WASTEWATER BASIN (ALREADY PRESENT) TO FERTIRRIGATION

NH3 — CONTROL AND COLLECTION SENSORS

Interreg Mediterranean - RE-LIVE WASTE

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

Interreg Mediterranean RE-LIVE WASTE

SERECO BIOTEST S.a.s.

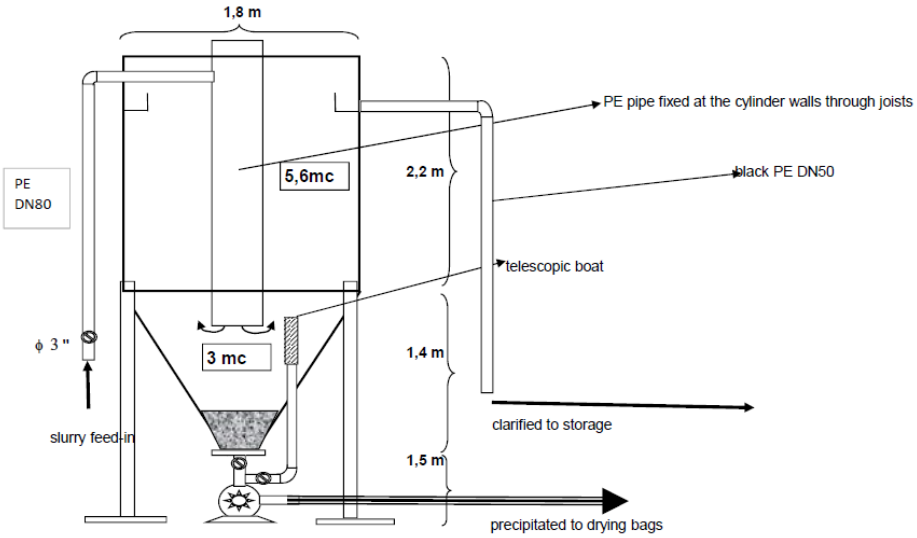
Sereco Biotest S.a.s. di Dinamo Nipote
Via C. Balbo, 7
06131 Perugia (Italy)
C.F. / P. IVA 00000000000

P&I AND SIDE VIEW TREATMENT PLANT BUTMIR BH

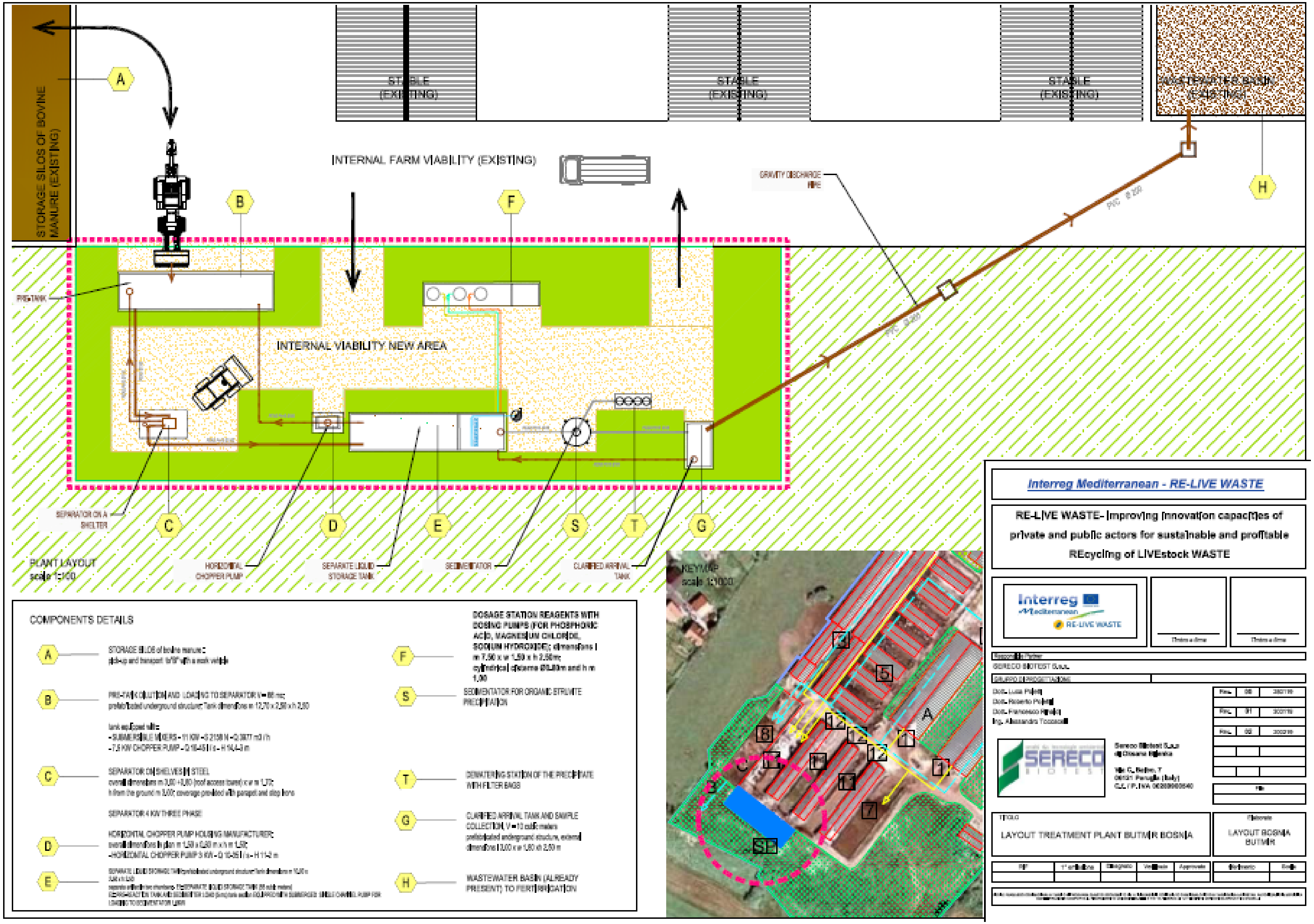
P&I BOSNIA BUTMIR

NOT IN SCALE

SETTLER SCHEME BUTMIR BOSNIA



Plating materials: stainless steel AISI 304
iron coated with epoxidic paint


STORAGE SILOS OF BOVINE MANURE (EXISTING)
STABLE (EXISTING)
STABLE (EXISTING)
STABLE (EXISTING)
WASTEWATER BASIN (EXISTING)
INTERNAL FARM VIABILITY (EXISTING)
INTERNAL VIABILITY NEW AREA
GRAVITY DISCHARGE PIPE
PRE-TANK
SEPARATOR ON A SHELTER
HORIZONTAL CHOPPER PUMP
SEPARATE LIQUID STORAGE TANK
SEDIMENTATOR
CLARIFIED ARRIVAL TANK
A
B
C
D
E
F
S
T
G
H
PLANT LAYOUT
scale 1:100
KEYMAP
scale 1:1000
COMPONENTS DETAILS
DOSAGE STATION REAGENTS WITH DOSING PUMPS (FOR PHOSPHORIC ACID, MAGNESIUM CHLORIDE, SODIUM HYDROXIDE)
SEDIMENTATOR FOR ORGANIC STRUVITE PRECIPITATION
DEWATERING STATION OF THE PRECIPITATE WITH FILTER BAGS
CLARIFIED ARRIVAL TANK AND SAMPLE COLLECTION
WASTEWATER BASIN (ALREADY PRESENT) TO FERTIRRIGATION
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LAYOUT TREATMENT PLANT BUTMIR BOSNIA
LAYOUT BOSNIA BUTMIR

PLANT ENERGY DEMAND TREATMENT PLANT BUTMIR BOSNIA-HERZEGOVINA			
list of electromechanical works	Installated electrical power (kW)	Work time (h)	estimated daily energy consumption (kWh/d)
SUBMERGED MIXER 1	11	6	66
SUBMERGED MIXER 2	11	6	66
SUBMERGED CHOPPER PUMP	7,5	5	37,5
SEPARATOR	4	5	20
HORIZONTAL SUBMERGED CHOPPER PUMP	3	5	15
SUBMERGED LOADING PUMP TO SEPARATOR	1,6	4	6,4
SUBMERGED DRAINING PUMP	1,6	1	1,6
COMPRESSOR	4	4	16
DOSING PUMPS 1	0,1	8	0,8
DOSING PUMPS 2	0,1	8	0,8
DOSING PUMPS 3	0,1	8	0,8
DOSING PUMPS 4	0,1	8	0,8
TOTAL	***44,1***		***228,5***

analisi r&s tecnologie ambientali
SERECO
BIOTEST

Interreg Mediterranean
Project co-financed by the European Regional Development Fund
RE-LIVE WASTE

Item No.	WORK DESCRIPTION	DIMENSIONS				Quantity	AMOUNT	
		par.ug.	length	width	H/weight		unit	TOTAL
1 NP.01	Supply and installation of prefabricated tanks with perfect watertightness, two with external dimensions of 2.46x12.7x2.5 and one of 1.8x3x2.5. All this including the excavation, the concrete bedding slab on the bottom, the backfill with sand and and backfill soil, the waste discharge of the surplus material. All made to perfection.					1,00		
	SUMMARY to body					1,00	35'000,00	35'000,00
2 NP.02	Arrangement of the construction site area including the plough of the entire area and arrangement of the road network and squares with road foundation formation in mixed grain size by mechanical compaction and insertion of non-woven fabric on the bottom. All made to rule of art.					1,00		
	SUMMARY to body					1,00	3'500,00	3'500,00
3 NP.03	Supply and installation of the electrical system at the service of the plant including power lines, connections, external distribution with corrugated, wells and general panel at the dosing station. All made to perfection					1,00		
	SUMMARY to body					1,00	5'750,00	5'750,00
4 NP.04	Supply and installation of a separation system consisting of a mechanical separator, support shelter, electrical connections, brackets, level sensors, automation and control panel, hydraulic connections and electromechanical service devices, as listed below. In the tank for homogenization tank, dilution and loading to the separator: two horizontal submersible mixers; a submersible chopper pump for loading. In the tank for the storage of the separated liquid (centrate): a horizontal chopper pump. Also included are the connected civil works such as the slab foundation and the support pole of the shelter. Everything is made to perfection in order to make the system fully functional. (For the characteristics of the mechanical devices see attached tables).					1,00		
	SUMMARY to body					1,00	75'000,00	75'000,00
5 NP.05	Realization of chemical dosing station including polyethylene tanks, stirrer, dosing pumps, connection pipes to the tanks, electrical and signal connections, power and control panel. It also includes the construction of a support concrete slab with construction of a brick structure with a sheet metal covering to protect the equipment. All made to perfection.					1,00		
	SUMMARY to body					1,00	8'500,00	8'500,00
6 NP.06	Supply and installation of sensors useful for the process control including signal and power wiring, installation in the tanks, such as pH and NH4 sensors. All made to perfection					1,00		
	SUMMARY to body					1,00	7'500,00	7'500,00
7 NP.07	Supply and installation of settler							

Item No.	WORK DESCRIPTION	DIMENSIONS				Quantity	AMOUNT	
		par.ug.	length.	width.	H/weight		unit	TOTAL
						1,00		
	SUMMARY to body					1,00	25'000,00	25'000,00
8 NP08	Supply and installation of O-SEP dehydration station equipped with filter bags							
						1,00		
	SUMMARY to body					1,00	17'000,00	17'000,00
	Partial WORKS TO MEASURE euro							177'250,00
	T O T A L euro							177'250,00
	Perugia, 20/02/2019							
	The technician in charge							

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	WP-3
Deliverable n. and title	D321 - Guidelines for data collection
Responsible Partner	Sereco Biotest
Participating partners	Lead partners in each project territories
Main authors	Roberto Poletti
Reviewers	Luca Poletti

DATA REQUESTED (where applies)	HINTS	YOUR ANSWER
COMPANY'S GENERAL DATA		
COMPANY'S NAME		PD Butmir
LOCALITY	city, district, state	Sarajevo, Bosnia and Herzegovina
MANAGEMENT	Individual, familiar, consortium, cooperative	State
TURNOVER[10] (€)		2.718.715,00
AREA (Ha)		263
PLANT PRODUCTION		
SPECIES 1	Corn, wheat, grain, barley, rye, etc.	Corn (silage)
PRODUCTION[2] (LAST YEAR)		5.139 t
CULTIVATION AREA (extension)	in ha	170
ESTIMATED PRODUCTIVITY	in t/ha	30,23
SPECIES 2	Corn, wheat, grain, barley, rye, etc.	Lucerne
PRODUCTION[3] (LAST YEAR)		415 t
CULTIVATION AREA (extension)	in ha	20
ESTIMATED PRODUCTIVITY	in t/ha	31,11
SPECIES 3	Corn, wheat, grain, barley, rye, etc.	Clover/grass mixtures
PRODUCTION[11] (LAST YEAR)		314 t
CULTIVATION AREA (extension)	in ha	73
ESTIMATED PRODUCTIVITY	in t/ha	4,3
Etc…		
ZOOTECHNICAL PRODUCTION		
SPECIES 1 (POULTRY)	Chickens, hens	-

[10] **Referred to the last year** [2] **Referred to the last year** [3] **Referred to the last year**

[11] **Referred to the last year**

			Average number of bred heads per year						
Categories (unit number)			Breeding class apportionment						
			Hens	Chickens	Broilers	Hens	Chickens	Broilers etc…	
			N°	N°	N°	N°	N°	N°	
Average weight per category (Kg)									
			Kg	Kg	Kg	Kg	Kg	Kg	
SPECIES 2 (SWINE)						-			
			Average number of bred heads per year						
Categories (unit number)			Breeding class apportionment						
			Pigs	Pigs fattening	Boars	Pigs	Pigs fattening	Boars ecc…	
			N°	N°	N°	N°	N°	N°	
Average weight per category (Kg)									
			Kg	Kg	Kg	Kg	Kg	Kg	
SPECIES 3 (CATTLE)			Specify: milk, meat			Milk			
			Average number of bred heads per year			502			
Categories (unit number)			Weight class apportionment						
			kg 150-300	kg 300-600		Kg 50-150	Kg 150-300	Kg 300-500	kg > 600
Average weight per category (Kg)									
						33	90	205	502
						tie stall housing system with straw as beeding material			

BREEDING SYSTEM	In general: sedentary/wild for birds: ground/in battery, for cattle: couchette,litter, etc…	

SUBSTRATE TO BE TREATED		
LIVESTOCK WASTE (mc/day)	manure, liquid manure, etc…	manure
WASTEWATER (mc/day)		60 mc/day
ANAEROBIC DIGESTATE (mc/day)		-
SUBSTRATE PRETREATMENTS		
STORAGE VOLUME (mc)		-
DEWATERING SYSTEM	centrifugal separator, flotation, settling tank, belt-press, etc…	-
WORKING CAPACITY	Specify measurement units: mc/h, l/h, l/min	-
SOLID CAPTURE YIELD (%)		-
SPECIFIC COSTS (€/mc)		-
CONSTRAINTS ON SOIL SPREADING		
AGRICULTURAL SURFACE SUBJECT TO SPREADING / FERTIGATION (ha)		73
AGRICULTURAL SURFACE VULNERABLE TO NITRATES (ha)		73

MINIMUM DISTANCE FOR SPREADING / FERTIGATION (Km)		2.0
MAXIMUM DISTANCE FOR SPREADING / FERTIGATION (Km)		6.0

SPECIFIC COSTS FOR SPREADING/ FERTIGATION (€/mc)		10.0
FERTILIZATION PLANS		
SPECIFIC USE OF N, P_2O_5, K_2O, MgO, ORGANIC CARBON (LAST YEAR) (Kg/ha)		NPK fertilizers: 400 kg/ha Urea: 100 kg/ha
AVERAGE COST OF FERTILIZATION PER HECTARE (LAST YEAR) (€/ha)		300.00

REQUIRED ATTACHMENTS:

• CHEMICAL ANALYSIS OF THE SUBSTRATE TO BE TREATED (raw manure, digestate, liquid fraction after dewatering) including at least the following parametres:

Mandatory:

- pH
- TS(Total Solids)
- NH_4
- Organic Nitrogen (NTK)
- PO_4 - Mg
- Ca
- K
- C org

Facultative:

- Density
- Viscosity
- Nitrate
- Nitrites
- Volatile fatty acids
- Analysis of potential pollutants:
    - Heavy metals o VOC_s
    - Pesticides

- PLANIMETRY (1:100 or 1:200) OF THE FACILITY eligible as testing SITE
- PLANIMETRY 1:2000 OF THE FACILITY SITE
- GEOGRAPHIC LOCATION (IMAGE FROM GOOGLE MAP)
- SCHEME OR PLAN OF THE ELECTRICAL SYSTEM (wiring, switchboards, etc…) available at testing site • PHOTOGRAPHIC REPORT OF THE TESTING SITE.

NOTE AND OBSERVATIONS might regard:

- Soil fertility (in this case please attach soil analysis)
- Highlight soil-related issues/problems (if applies)
- Legislative framework
- Particular obstacles, constraints, difficulties, etc…
- Presence of local technicians available at site and relative qualification (plumber, electrician, chemist, engineer, plant operator, etc…)

ATTACHMENTS:

- testing farm google map
- testing farm sheme
- testing farm photos
- Chemical composition of manure
- PD BUTMIR - note and observations

Date 26.9.2018. Signature

Emir Dzomba

PHOTO: PD BUTMIR, Bosnia and Herzegovina

Photo 1. Area planned to SERMAP installation

Photo 2. Manure storage

Photos 3-4. Tie stall barns

Photo 5. Wastewaters storage

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

Technical report Butmir

FINAL VERSION

10/02/2021

Project title and acronym	RE-LIVE WASTE
Work Package	WP3
Deliverable n. and title	D332 – TECHNICAL REPORT
Responsible Partner	SERECO BIOTEST SAS
Participating partners	SERECO BIOTEST SAS – SERDA – UNIVERSITY OF SARAJEVO
Main authors	Dr. BIOL LUCA POLETTI, ING. ALESSANDRO TOCCACELI, Dr. FRANCESCO RINALDI
Reviewers	Dr. AGR. ROBERTO POLETTI Dr. ANDREA BRUGONI

Overview description of the testing initiation procedures at Butmir

Introduction

As TIP (Testing Initiation Procedure) we refer to all the technical activities carried out in order to set out the appropriate working regime of the plant and let the local workers be able to attend at its functioning in an autonomous way.

It was planned to undertake at least three TIPs with the aim of acquiring an adequate data base upon which conduct, just in case, a minimal statistical analysis.

The purpose of the experimentation relies on the considerations outlined in the SOTAR report to which reference must be made.

Here we can simply remind that in the bosnian case study the material that was taken into consideration for the application of the SP reaction is cattle raw slurry being submitted to a dewatering procedure by means of a newly-acquired centrifuge, which represents the most relevant innovation feature put into practise at Butmir. In this way, in the present study the Struvite Precipitation (SP) was conducted on the centrate coming out of the centrifuge operating the dewatering on the raw cattle slurry.

For budget reason the experimental plant being constructed does not comprise the sedimentation and pressurized bag filtration units that were initially thought of in the SOTAR.

We think that the absence of these down processing technological units does not affect the demonstration activity whose primary aim is the feasibility assessment of the SP reaction in terms of effectiveness of NH_4 abatement. The technological refinement of the down process will be the aim of future improvement actions.

Plant description

The plant used for the experimentation is the one designed according to the project attached to the SOTAR and relative annexes (D 3.2.2.). The functional flow diagram of the plant is reported in Fig.1 whereas in Fig.2 is reported the P&I side-view

Differently than what had been envisaged, the currently running pilot SP plant does not entail items No.10 and 11. (corresponding to S and T in Fig. 2).

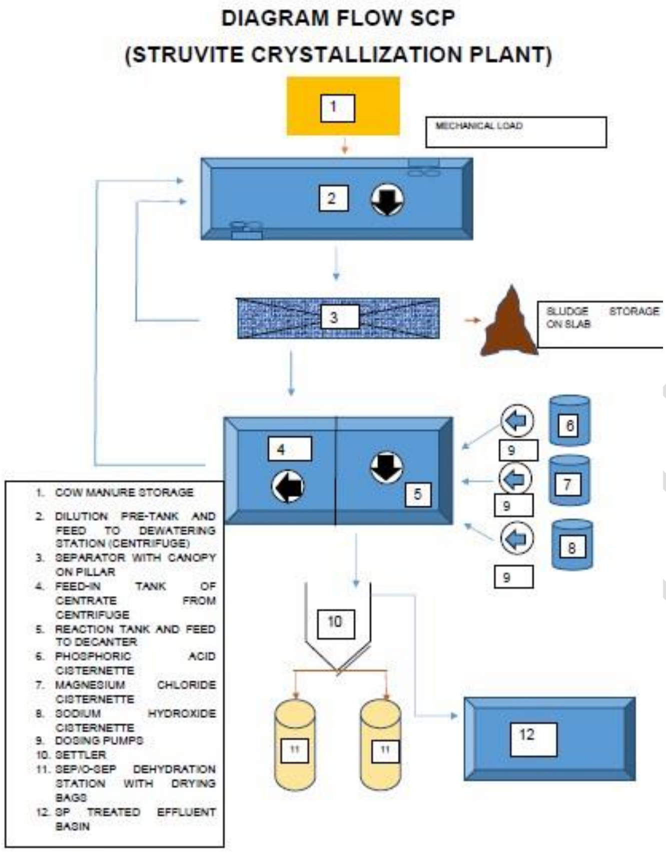


Fig. 1 Functional Flow Diagram of the testing plant

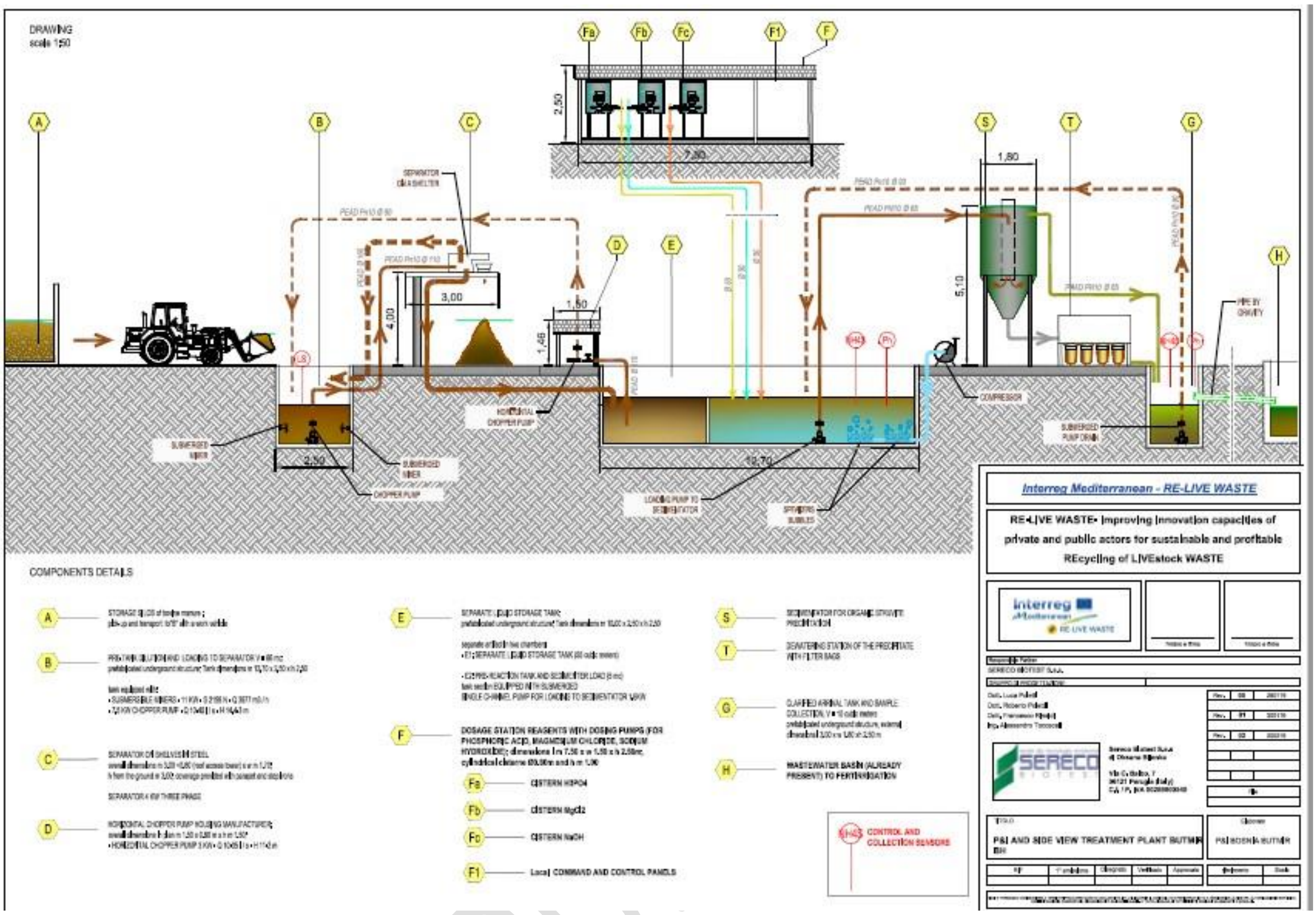


Fig. 2 Side view of the functional scheme

Activity description

The TIP at Butmir was conducted in remote way due the COVID restrictions for travelling.

A first session was carried out on 29/7 in which a batch of centrate derived from the centrifugation of raw cow manure was submitted to SP.

However, several problems did arise. Indeed, there was a clogging in the pumping system operating the loading of the raw manure to the centrifuge due to the presence of an unexpected quantity of straw fibres.

After the resolution of this setback, it was checked whether the positioning of the sensors could affect the measurement output.

As expected, the levels of pH, NH_4 and K measured on-line significantly changed when the sensors were moved from the wall to the centre of the tank, as it can be seen in the following table.

	N-NH_4	**K**	**pH**
WALL	636	532	7,88
CENTRE	577	814	7,96

It was then decided to take as a reference the measurements obtained when the sensors were positioned in the centre of the Reaction Tank (RT).

Then a stripping test was started by aerating the tank for 4 hours by means of bubbling diffusers positioned at the bottom of the RT. A vigorous aeration in this way conducted is expected to blow off CO_2 (thus raising the pH and saving on the NaOH utilization) and NH_3 (thus favouring the NH_4 abatement).

A raising in pH (from 6.95 to 7.51) was observed along with an increase in the N-NH_4 concentration (from 990 to 1091 mg/l). N-NH_4 has raised probably in reason of a better influent mixing promoted by the bubbling system that prevailed on the expected NH_4 escaping.

After the accomplishment of the stripping phase, the introduction of the reagents was carried out in the amount of 14 l of H_3PO_4 and 15.6 l of $MgCl_2$ within 42' and 47' loading time, respectively.

After that, it was decided to stop the test because the monitoring system seemed not to response appropriately and it was thought that a new calibration had to be attended.

The result was as follows:

N-NH_4	**K**	**pH**
743	532	6,30

The pH remained low thus suggesting the fact that struvite precipitation reaction did not take place.

Despite that, there was a not negligible reduction of the concentration of NH_4 (about -32%).

After that, the TIP had problems concerning the pumping system (clogging of the loading pump from the storage of the raw manure into the centrifuge) and the sensors for pH and NH_4, that needed checking and calibration with standard solutions several times.

After the resolution of the problems encountered, everything was ready to finally carry out three fullrun tests: TEST No.1 on 18.11.2020, TEST No.2 on 03.12.2020 and TEST No.3 on 10.12.2020.

The modalities of conduction and the results obtained are described in details in the following sections.

Materials used (reagents and sensors)

For the experimentation, the following reagents were used:

- $MgCl_2$ (CAS 1309-48-4) liquid, with a 51% purity grade;
- H_3PO_4 liquid, with a 75% purity grade;
- NaOH liquid, with a 50% purity grade.

The sensoring equipment for the on-line monitoring of pH, NH4 and K using The IQ SENSORNET System 28X as a modular measuring system with two sensors: (i) SensoLyt® 700 IQ (SW) for pH measuring (equipped by temperature sensor) and (ii) AmmoLyt®Plus 700 IQ equipped with three electrodes: for ammonia, potassium and reference electrodes.


Descritpion of the testing procedures

TEST 1 (18.11.2020)

The diffusive stripping was kept running for 3h 40'. There was a significant increase of pH (from 7.60 to 8.20) and a negligible decrease in $N\text{-}NH_4$ (from 580 to 558 mg/l, -4%).

After the completion of the stripping phase, that is when the pH and the NH_4 values transmitted by the sensors stabilized, the introduction of the reagents was launched. $MgCl_2$ and H_3PO_4 were added at the same time with the point of introduction in the reaction tank being set nearly at the bottom of the RT, in order to assure the higher degree of mixing. The same occurred in the subsequent tests. The volume quantities of the reagents were calculated based on the values given by the sensors for what concerns $N\text{-}NH_4$ and on the lab values provided by the University of Sarajevo for the remaining parameters (PO_4, Mg and Ca). The litres of H_3PO_4 and $MgCl_2$ entered in the RT for a 3.3 m^3 reaction liquor volume were 10.3 and 10.7, respectively, calculated upon a proprietary calculation routine provided by Sereco based on the sensor-provided NH_4 value.

TEST 2 (03.12.2020)

The diffusive stripping was kept running for 3h 16’. There was a very significant increase of pH (from 7.22 to 8.12) and a significant decrease in N-NH_4 (from 502 to 446 mg/l, -12%).

The litres of H_3PO_4 and $MgCl_2$ entered in the RT for a 3.0m^3 reaction liquor volume were 10.7 and 5.1 l respectively, calculated upon a proprietary calculation routine provided by Sereco. In this test case the initial Mg value of the influent centrate measured in laboratory turned out to be considerably higher than that for TEST 1 (364 mg/l vs. 155 mg/l) along with a substantial higher value of Ca (674 mg/l vs. 224 mg/l). Therefore, less external Mg was added.

Moreover, in the attempt of overcoming the Ca excess that could have impaired the MAP precipitation due to the competitive action of PO_4-sequestring Ca (giving rise to amorphous $Ca_3(PO_4)_2$, it was decided to raise the MR (Molar Ratio) of PO_4 with respect to NH_4 and Mg. As a consequence, the volume quantity of H_3PO_4 being loaded in the RT was higher than in TEST 1

TEST 3 (10.12.2020)

The diffusive stripping was kept running for 3h 45’. There was a weak increase of pH (from 7.80 to 8.10) in contrast with a significant decrease in N-NH_4 (from 590 to 446 mg/l, -9%).

In this case, a higher pH initial value was observed probably due the residues of the previous tests not being fully drawn off from the reaction tank.

The litres of H_3PO_4 and $MgCl_2$ entered in the RT for a 3.0 m^3 reaction liquor volume were 14.3 l and 8.8 l respectively, calculated upon a proprietary calculation routine provided by Sereco. The criterion for the MR to be used was the same as for test 1.

The operational details are presented in Annex 1 “Experimental Notebook”

SOTAR _ RESULTS

1. **SP LIQUID STREAM**

Project co-financed by the European Regional Development Fund

RE-LIVE WASTE

Table 1 – Comprehensive overview of the analytical results referred to the liquid stream

TEST 1 12-11-2020				**TEST 2 03-12-2020**				**TEST 3 10-12-2020**			
		START	**END**			**START**	**END**			**START**	**END**
ST 105°C	%	1,45		ST 105°C	%	2,45		ST 105°C	%	3,71	
pH	pH u.	**8,20**	**8,5**	**pH**	pH u.	**8,12**	**8,81**	**pH**	pH u.	**8,09**	**8,5**
NH_4	mg/l NH4	747	341	**NH_4**	mg/l NH4	573	333	**NH_4**	mg/l NH4	759	477
PO_4	mg/l	387	100	**PO_4**	mg/l	246	7091	**PO_4**	mg/l	269	1752
Mg	mg/l	155	112	**Mg**	mg/l	364	1025	**Mg**	mg/l	308	1130
Ca	mg/l	224	164	**Ca**	mg/l	674	336	**Ca**	mg/l	320	328
K	mg/l	1185	945	K	mg/l	964	813	K	mg/l	190	755
Test volume	l	3300		Test volume	l	3000		Test volume	l	3000	
NaOH input	l		36	NaOH input	l		28,5	NaOH input	l		46
NaOH input	**% v/v**		**1,1**	**NaOH input**	**% v/v**		**0,9**	**NaOH input**	**% v/v**		**1,5**
$[PO_4]$ input	mg/l		3556	**[PO4] input**	mg/l		3685	**[PO4] input**	mg/l		4939
[Mg] input	mg/l		841	**[Mg] input**	mg/l		400	**[Mg] input**	mg/l		691
TOT $[PO_4]$	mg/l		3943	TOT $[PO_4]$	mg/l		3931	TOT $[PO_4]$	mg/l		5208
TOT [Mg]	mg/l		996	TOT [Mg]	mg/l		764	TOT [Mg]	mg/l		999

NH_4			NH_4			NH_4		
[NH_4] end/start	%	45,6	[NH_4] end/start	%	58,1	[NH_4] end/start	%	62,8
NH_4 ABAT	%	54,4	NH_4 ABAT	%	41,9	NH_4 ABAT	%	37,2
PO_4			PO_4			PO_4		
PO_4 end/tot	%	2,5	PO_4 end/tot	%	180,4	PO_4 end/tot	%	33,6
PO_4 PREC YIELD	%	97,5	PO_4 PREC YIELD	%	-80,4	PO_4 PREC YIELD	%	66,4
PO4 end/start	%	26	PO4 end/start	%	2883	PO4 end/start	%	651
PO_4 ABAT	%	74,2	PO_4 ABAT	%	-2783	PO_4 ABAT	%	-551
Mg			Mg			Mg		
Mg end/tot	%	11,24	Mg end/tot	%	134,16	Mg end/tot	%	113,11
Mg PREC YIELD	%	88,8	Mg PREC YIELD	%	-34,2	Mg PREC YIELD	%	-13,1
Mg end/start	%	72	Mg end/start	%	282	Mg end/start	%	367
Mg ABAT	%	28	Mg ABAT	%	-182	Mg ABAT	%	-267
Ca			Ca			Ca		
Ca end/start	%	73,2	Ca end/start	%	49,9	Ca end/start	%	102,5
Ca ABAT	%	26,8	Ca ABAT	%	50,1	Ca ABAT	%	-2,5

The “start” values for pH and NH_4 are those measured on-line by the sensors, while in all other cases the parametres were tested in laboratory.

By ”TOT” PO_4 and “TOT Mg” it is meant the sum of PO_4 and Mg already present in the influent liquor to the SP and the quantity of those reagents introduced as external chemicals

“NH_4 ABAT” is the percentage of NH_4 being abated by means of the whole process (including preliminary stripping). Likewise, “PO_4 ABAT” and “Mg ABAT” are intended in terms of how much the original amount of these species, that is the quantity being conveyed by the influent to the SP, has decreased by means of the adopted process.

By “PREC YIELD” it is meant the percentage of the overall (that is included the initial) PO_4 and Mg concentration present in the liquor after the introduction of the external reagents being subtracted from the liquid phase through precipitation. This parameter gives an account of how smoothly and efficiently the SP takes place.

As it can be seen from Tab. 1, the overall NH_4 abatement yields results satisfactory, ranging from the 54.4% of TEST 1 to 37.2% of TEST 3.

It is worthy to note that a not negligible contribution to the NH_4 abatement is given by the stripping preliminary treatment, 12% in TEST 2 (about 1/3 of the total abatement yield) and 9% in TEST 3 (about ¼ of the total abatement yield).

When we observe the precipitation yields of PO_4 and Mg we can notice that these values are very high in TEST 1 and moderate but acceptable in TEST 3. On the other hand, in TEST 2 we are in the presence of an overwhelming excess of both PO_4 (very high) and Mg. This can be explained by a possible retention of a part of the precipitated/reacted liquor produced in the previous test that was not entirely pumped off from the RT.

Likewise, the abatement dynamics of PO_4 also follows this pattern with a very good result achieved in TEST 1 (-74.2%) not replicated in the subsequent two tests. The influent Mg in TEST 1 was not recaptured as successfully as PO_4 in TEST 1, with a slightly excess remained in solution after SP. Despite that, the result can regarded as satisfactory if we consider that Mg is not among the target nutrients to be catched in the precipitation-driven recovery.

Lastly, it is noteworthy to observe that the disappearance of Ca from the liquid phase and so its undesirable precipitation in the O-SEP solid phase is extremely limited and even virtually absent, like in TEST 3.

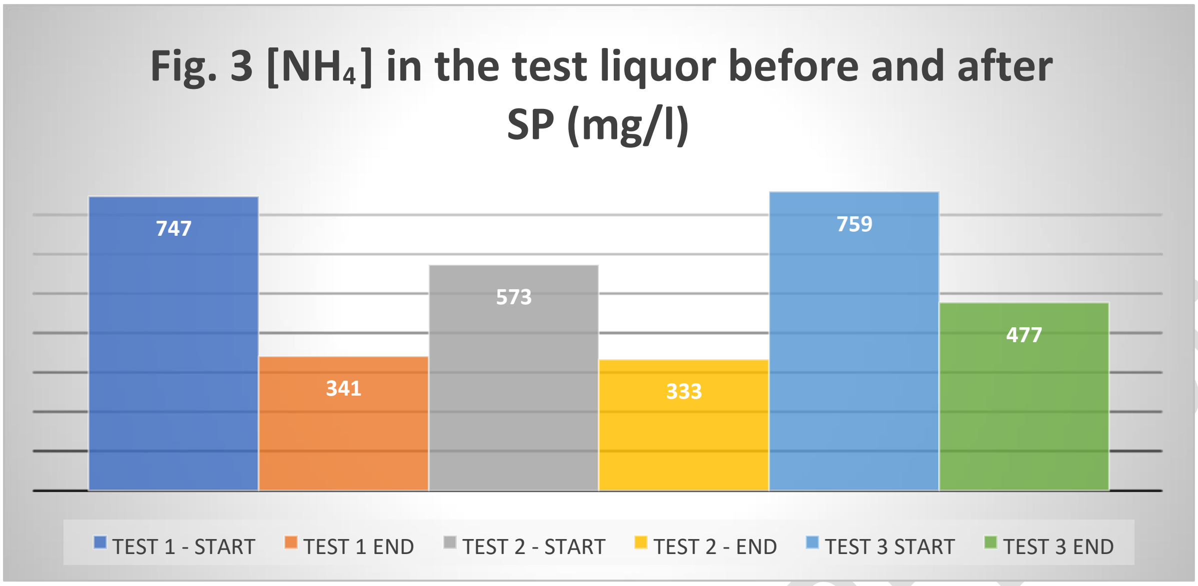


Fig. 3 [NH4] in the test liquor before and after SP (mg/l)
747
341
573
333
759
477
TEST 1 - START
TEST 1 END
TEST 2 - START
TEST 2 - END
TEST 3 START
TEST 3 END

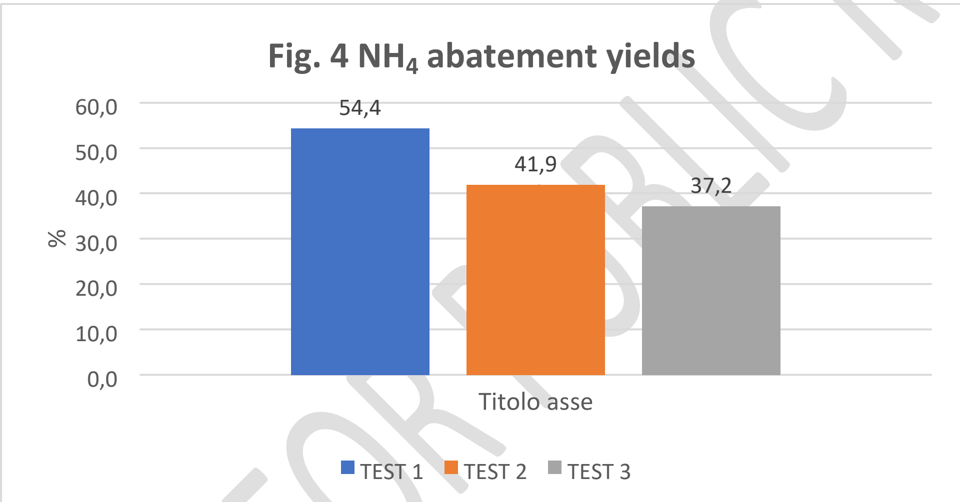


Fig. 4 NH4 abatement yields
60,0
50,0
40,0
30,0
20,0
10,0
0,0
%
54,4
41,9
37,2
Titolo asse
TEST 1
TEST 2
TEST 3

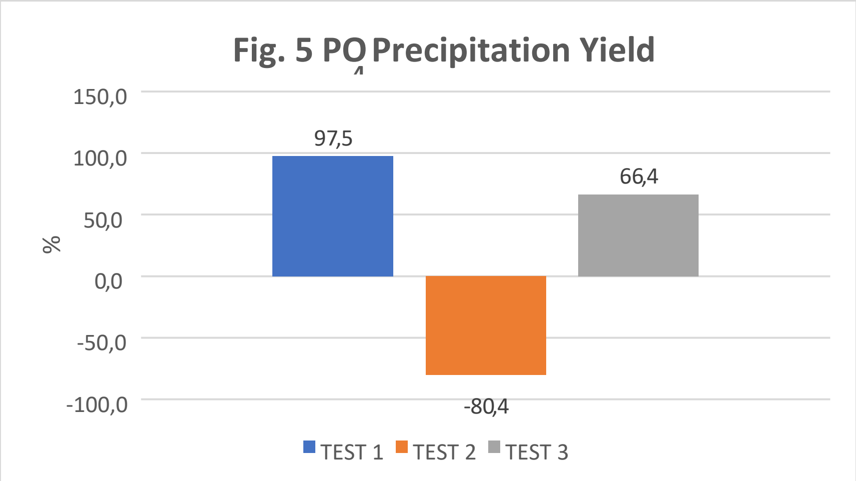


Fig. 5 PO4 Precipitation Yield
150,0
100,0
50,0
0,0
-50,0
-100,0
%
97,5
-80,4
66,4
TEST 1
TEST 2
TEST 3

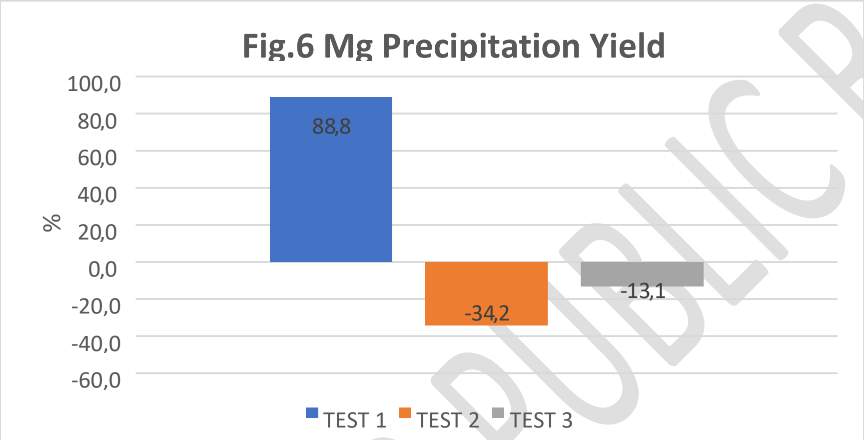


Fig.6 Mg Precipitation Yield
100,0
80,0
60,0
40,0
20,0
0,0
-20,0
-40,0
-60,0
%
88,8
-34,2
-13,1
TEST 1
TEST 2
TEST 3

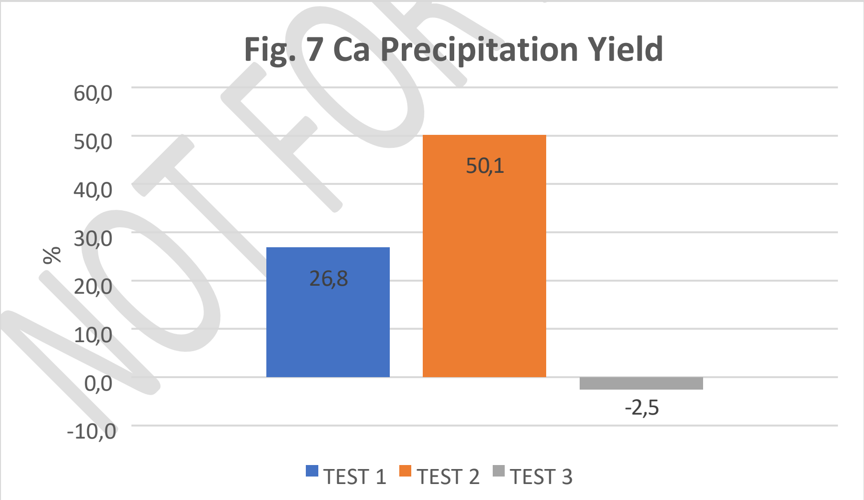


Fig. 7 Ca Precipitation Yield
60,0
50,0
40,0
30,0
20,0
10,0
0,0
-10,0
%
26,8
50,1
-2,5
TEST 1
TEST 2
TEST 3

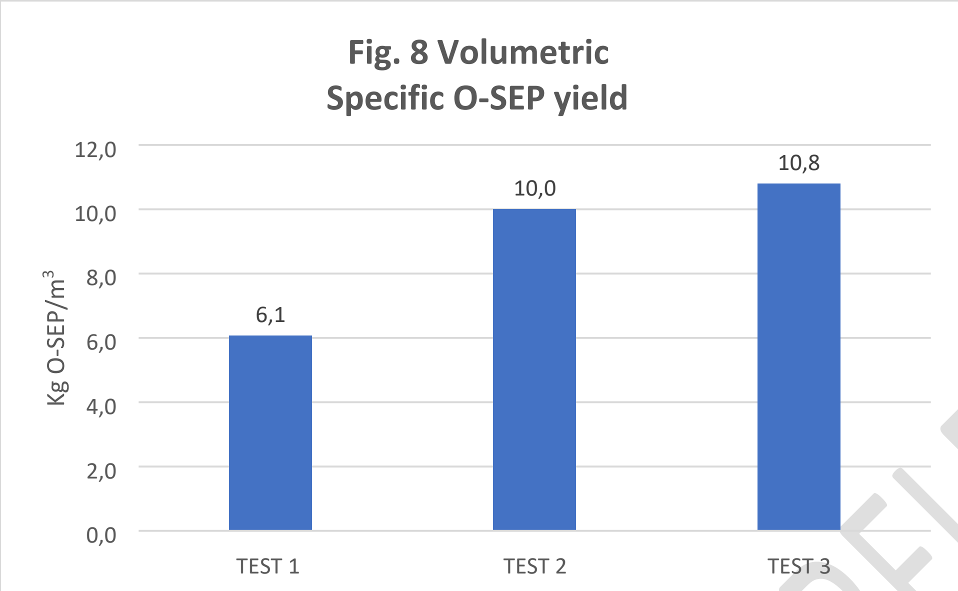
2. <u>SP SOLID STREAM</u>

Tab.2 ANALYTICAL RESULTS OF THE O-SEP CHRACHTERIZATION

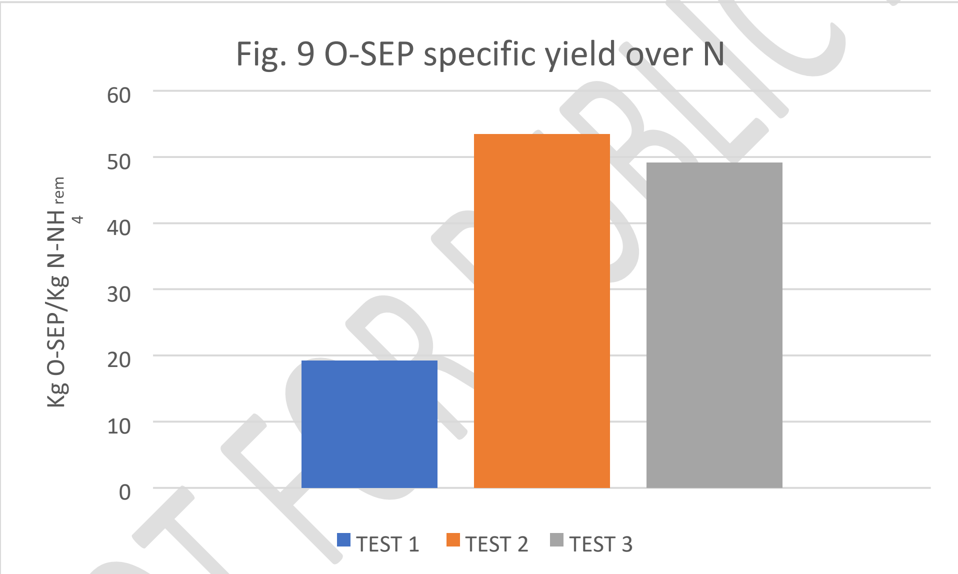
					TEST 1		**TEST 2**	**TEST 3**
PS 40°C				g	17000		25000	27000
Treated volume				litres	2800		2500	2500
O-SEP 40°C				%	0,61		1	1,08
O-SEP specific yield				**Kg O-SEP/m^3**	**6,1**		**10,0**	**10,8**
N-$NH4_{rem}$				g N-$NH_{4\ rem}$	887		468	550
Kg OO-SEP specific yield over N_{rem}				**SEP/Kg N-$NH_{4\ rem}$**	**19**		**53,4**	**49,1**
NH_4	**%**	**2,66**	**2,06**	**1,40 Ptot**	**%**	**5,86**	**4,75**	**4,40 Mg**
	%	**4,74**	**3,88**	**4,10**				
Ca	**%**	0,95	1,12	1,27 K %	0,92	0,98	1,07	
Na				%	1,09		0,99	1,18
TOC	%	**22,3**	**23,2**	**26,6** SO %	38,4	40,0	45,9	
Ntot Kjeldahl				**%**	**3,40**		**3,51**	**3,13**
N-NH_4				%	2,05		1,59	1,08
P_2O_5				**%**	**13,4**		**10,9**	**10,1**
MgO				%	**7,9**		**6,4**	**6,8**
CaO				%	**1,33**		**1,57**	**1,78**
K_2O				%	**1,11**		**1,18**	**1,29**
Na_2O				%	**1,47**		**1,33**	**1,59**

Tab.2 summarizes the main analytical results concerning the characterization of the solid precipitate named O-SEP (Organic Struvite-Enriched Precipitate).

The O-SEP specific yield ranges between 6 Kg and 10.8 Kg O-SEP /treated m^3 (Fig.8). The fact that this figure raises going from TEST 1 to TEST 3 lend support to the hypothesis, already outlined in the previous paragraph, that the RT, for not being fully emptied from one test to the other, acts as a sort of sludge accumulator or even a settler.



The O-SEP specific yield with reference to the abatement of N is reported in Fig. 9. In this case TEST 2 performs better then TEST 3.



The chemical composition of the O-SEP as regards to the main nutrient components can be conveniently examined by looking at Fig 10, Fig. 11 and Fig. 12.

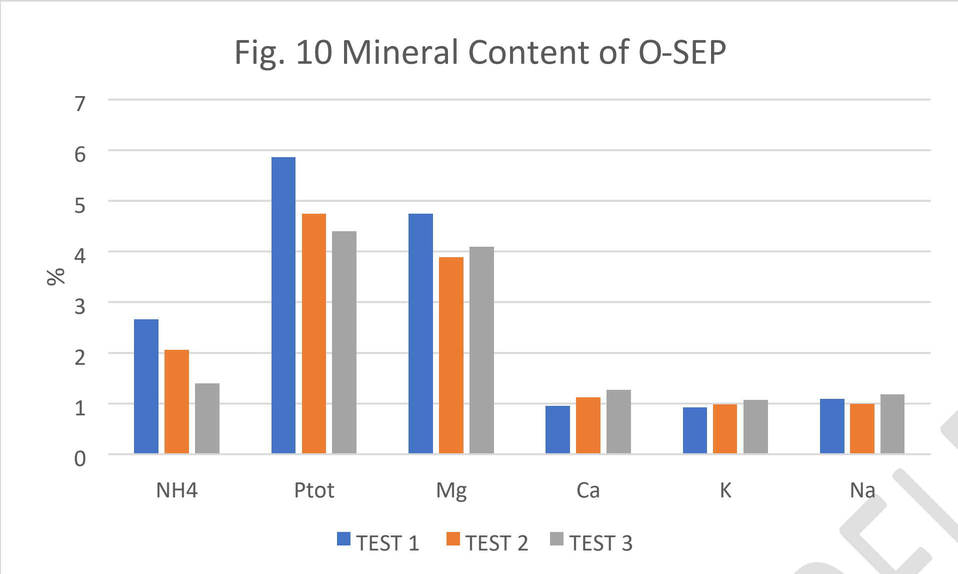


Fig. 10 Mineral Content of O-SEP
%
0
1
2
3
4
5
6
7
NH4
Ptot
Mg
Ca
K
Na
TEST 1
TEST 2
TEST 3

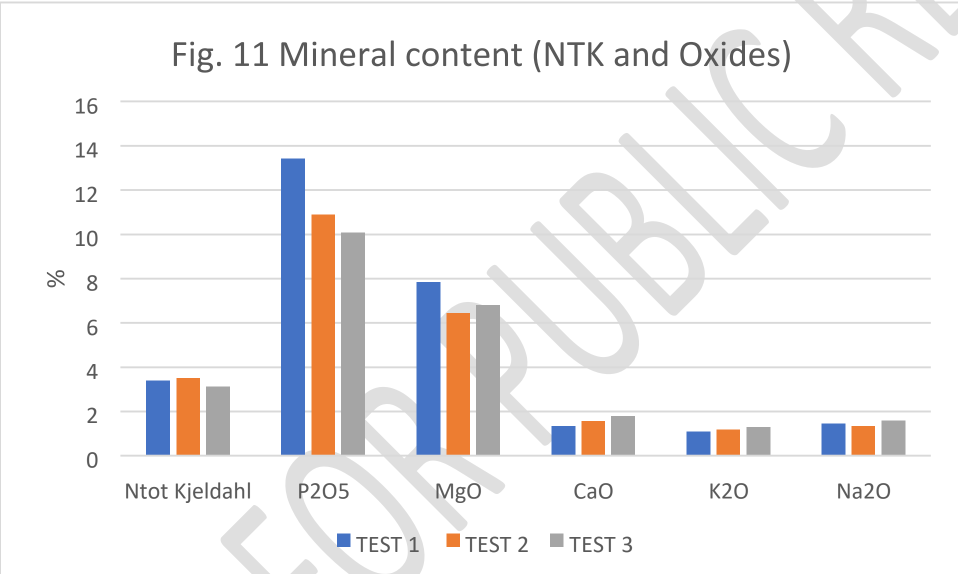
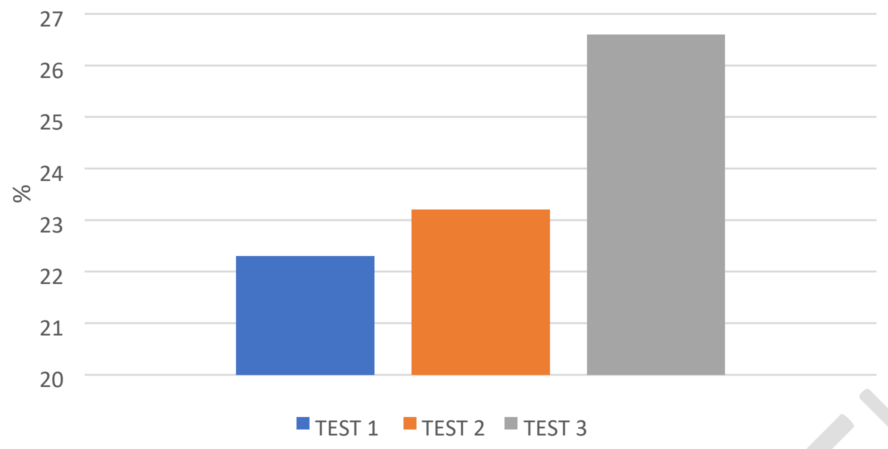


Fig. 11 Mineral content (NTK and Oxides)
%
0
2
4
6
8
10
12
14
16
Ntot Kjeldahl
P2O5
MgO
CaO
K2O
Na2O
TEST 1
TEST 2
TEST 3

Fig. 12 TOC content



An inverse correlation between the mineral and the organic content can be easily made out.

The overall supply of nutrients contained in the precipitates can undoubtedly be considered appealing.

The Proximate Analysis that represents the degree of similarity of the O-SEP to a theoretical pure struvite reveals a favourable pattern (Table 3).

Tab. 3 PROXIMATE ANALYSIS for the calculation of the presumable struvite content within the O-SEP

		PA - DEVIATIONS (%)	Normalization over OM			PA - DEVIATIONS (%) nSO
	THEOR % in MAP	**TEST 1**				**TEST 1**
$N\text{-}NH_4$	6	**-65,9**	N nOM	%	3,33	**-44,5**
P	13	-54,9	Ptot nOM	%	9,52	-26,8
Mg	10	-52,6	Mg nOM	%	7,70	-23,0
		TEST 2				**TEST 2**
$N\text{-}NH_4$	6	**-73,6**	N nOM	%	2,64	**-55,9**
P	13	-63,5	Ptot nOM	%	7,92	-39,1
Mg	10	-61,2	Mg nOM	%	6,47	-35,3
		TEST 3				**TEST 3**
$N\text{-}NH_4$	6	**-82,0**	N nOM	%	1,99	**-66,8**
P	13	-66,2	Ptot nOM	%	8,13	-37,5
Mg	10	-59,0	Mg nOM	%	7,57	-24,3

The deviations from an ideal condition in the 3 test ranges between 66% (TEST 1) and 82% (TEST 2), if we take into account the most distant from ideality of the 3 struvite basic constituents (N, intended as N-NH_4, P and Mg).

This can be interpreted as though the struvite content in the precipitate varies between 100-66 = 34% and 100-82% = 18%.

However, if we normalize the struvite content over the percentage of organic matter, that is if we discard the organic matter and consider only the mineral part of the precipitate, things look considerably better. In this case, the PA deviations oscillate between 44.5% (TEST 1) and 66.8% (TEST 3), meaning that the presumable struvite content is comprised between 55.5% and 33.2%.This is an encouraging result.

Further insights into the actual struvite content of the O-SEP can be given by resorting to crystallographic solid-state analytical techniques (DRX, SEM-EDS).

3. Dewatering effectiveness

Tab. 4 Analytical results of the Raw Slurry and the Centrate (centrifuge output) for TEST 2 and TEST 3 (data for TEST 1 not available)

		TEST 2 RS	TEST 2 CEN	TEST 3 RS	TEST 3 CEN
pH		**7,11**	**7,26**	**7,62**	**8,03**
TS	**%**	**5,87**	**3,25**	**6,32**	**3,71**
NH_4	**mg/L**	**580**	**646**	**923**	**760**
Norg	**mg/L**	**1170**	**964**	**1254**	**1069**
TN	**mg/L**	**1750**	**1610**	**2177**	**1829**
Ca	**mg/L**	**811**	**674**	**1068**	**993**
Mg	**mg/L**	**321**	**364**	**510**	**480**
K	**mg/L**	**1123**	**964**	**1059**	**775**
Na	**mg/L**	**712**	**623**	**302**	**548**
PO_4	**mg/L**	**237**	**246**	**629**	**992**
Cl	**mg/L**	**4,89**	**5,72**	**1,31**	**5,91**

LEGEND RS = Raw Slurry CEN = Centrate

Tab. 5 Analytical results of raw solid manure after separation

SOLID MANURE		TEST 2	TEST 3
AFTER SEPARATION			
Parameters	**Units**		
DM	**%**	22,14	24,32
Ca	**mg/kg**	768	967
Mg	**mg/kg**	498	967
K	**mg/kg**	1043	812
Na	**mg/kg**	654	682
PO_4	**mg/kg**	592	1459
Cl	**mg/kg**	126	227
TN	**mg/kg**	7912	8657

Tab. 6 Comparison of TS % (Total Solid) between raw manure (centrifugation input) and solid manure after centrifugation

		TEST 2 RS	TEST 2 SM	TEST 3 RS	TEST 3 SM
TS	**%**	**5,87**	**22,14**	**6,32**	**24,32**

LEGEND

RS = Raw Slurry

SM = Solid Manure

Tab.6 shows that the dewatering yield of the centrifuge has been extremely satisfactory with a more than 3 times solid thickening achieved. The result is in line with the typical performance of centrifugation systems for biological WWTP sludges.

Tab.4 clearly illustrates the effect of the SL separation in terms of solid reduction and consequent nutrient capture on the solid fraction. This occurs in all cases except that for NH_4 in TEST 2 and PO_4 in TEST 3 (see.Tab.7). In addition, Mg, PO_4 and Cl in TEST 2 look to be undercaptured, although not in a significant way. Of course, more data should be needed to confirm the pattern.

Tab. 7 Dewatering efficiency

	TEST 2 Dweff %	TEST 3 Dweff %	Dweff % exp
TS	44,6	41,3	28-78
NH_4	-11,4	17,7	n.a.
Norg	17,6	14,8	n.a.
TN	8,0	16,0	10-37
Ca	16,9	7,0	1,5-39
Mg	-13,4	5,9	1,5-39
K	14,2	26,8	1,5-39
Na	12,5	-81,5	1,5-39
PO_4	-3,8	-57,7	33-74[1]
Cl	-17,0	-351,1	n.a.

[1] Referred to P_2O_5

LEGEND

Dweff % = Percentage of dewatering Dweff % exp = Percentage of dewatering as expected in the SOTAR

As it can be seen from Tab.7 all the expected dewatering performances have been substantially met except than for PO_4.

It is intriguing to assess whether the hypothesis on the nutrient abatement and recovery through SP set out in the SOTAR document (pag. 12-15) is confirmed with the experimental data attained in the 3 TIP TESTS.

Tab.8 reports the actualized calculations based on the most recent analytical data concerning raw manure.

Tab. 8. Simulation sheet concerning the fertigation and land availability issues (part 1)

1. CHEMICAL COMPOSITION MANURE "as is"

	Kg/m³		SE % act	AVG	C Kg/m³
TS %	6,1		43,0	1,73	
Total N mg/l	1964	1,964	12,0	0,52	
N-NH4 mg/l	587	0,587			
PO4 mg/l	433	0,433	3,1	0,38	
Ca mg/l	940	0,94	-30,8	0,83	
K mg/l	1091	1,091	12	0,96	
Mg mg/l	416	0,416	20,5	0,37	
			-3,8		

2. HYDRAULIC AND SOLIDS FLOW-RATES

Qtot t/y	6550	
TS t/y	400	
CS_SLU t/y	172	
TSslu%	0,25	**Hypothesized**
TSslu t/y	43	
SLU t/y	687	
LIQ aft DEW t/y	5863	

Tab. 8 (part 2)

3. NUTRIENT LOADS FOR FERTIGATION

	Kg/y	%
Total N as is	74,2	
N-ORG		
N-NH4 as is	69,6	
TOTAL N -ORG		9019

	Kg/y
Total N sludge	1544
N-NH4 sludge	399

	Kg/y
Total N centrate	11320
N-NH4 centrate	3446

%N-ORG as	N-ORG	
	12864 is	sludge
	3845 70,11	centrate

	Kg/y
N-ORG sludge	1145
N-ORG centrate	277

4. LAND AVAILABILITY

	Ha		Kg/y		Kg/y
Fert land	73	Exc N Max N load	12410	OCLAV	454
		Exc Ncentr		OCLAV	-1090

	Ha
Extra land	3
Extra land$_{centr}$	-6,4

5. N ABATEMENT RATES

N-NH4 SP ABATEMENT	Kg/y	N TOT DEW ABATEMENT	Kg/y
33%			
Sludgeretained N +SEP retained N-			
SEP-retained N-NH4	1137	NH4	2681
Effluent N-NH4	2309		

Tab. 8 (part 3)

6. LAND SAVINGS

	Ha		Ha	
DEW Land SPLand saving	6,7	saving	9,1	**SP+DEW Land saving 15,8**

7. SEP PRODUCTION

	Kg/Kg N-NH_4		**t/y**
Specific O-SEP production	49	**O-SEP harvested**	**56**

LEGEND

SE = Separation Efficiency = How much is captured by the solids in the centrifuge

Qtot = total yearly manure production “as is”

TS = total solids in manure “as is”

CS_SLU = Captured solids in slurry after dewatering

TSslu% = Total solids in % in dewatered slurry

TSslu = Total solids in mass in dewatered slurry

SLU = Slurry produced after dewatering

LIQ aft DEW = Total liquid flow rate after dewatering

Exc N OCLAV = Exceeding N Over Current Land Availability

Exc Ncentr OCLAV = Exceeding N Over Current Land Availability coming from the centrate

Note: all the N calculations were based on the average SE and C values

For the calculation of the NH_4 abatement rate (considered as N-NH_4 abatement rate, conversion factor = 0.78) and the O-SEP yield per N-NH_4 removed as the median values across the three performed tests were taken.

The comparison with the assessment done in the SOTAR enlightens the fact that a significant change in the values of the main parameters concerning raw manure has occurred. With this adjustment taken into account a few considerations can be made:

1. The extra-land needed for spreading under the provisions of the Nitrate Directive is much lower than expected (3 Ha instead of 50 Ha). If we leave out the sludge nitrogen that can be easily handed out of the farming system and only consider the nitrogen contained in the liquid centrate, we even obtain a land credit of 6.4 Ha.
2. The adoption of centrifugation and SP as means to capture nitrogen and concentrate it in solid materials easy to be disposed or re-utilized elsewhere, produces a land saving for fertigation of 6.1 Ha and 6.7 Ha for sludge and O-SEP respectively, for an overall land use saving of 15.8 Ha
3. The yearly expected production of O-SEP is 56 t at a 33% NH_4 abatement rate

Conclusions

A first aspect to be considered is that the installation of the centrifugation has been for Butmir farm a groundbreaking innovation for two reasons:

1. A solid matter bearing fertilizing properties can be recovered
2. The nitrogen recovered in the solid sludge subtracted from the liquid phase favours the compliance of the fertigation procedure with the Nitrate Directive

In addition, the centrifugation favours the subsequent SP process as far as the liquid stream reduces the solid content.

The mixing mechanism in the RT proved to be effective in all tests by providing a good gas stripping. That produced a slight decrease of NH_4 and an increase of pH in the reaction liquor (due to the strip off of CO_2) giving a contribution to the cost-effectiveness of the process. In this respect, the use of the submergible bubbling diffuser seemed to be a right choice.

The devices used for monitoring NH_4 and pH had some calibration problems in the beginning. Afterwards, the system proved very stable and reliable thanks to an ISE (ion-selective electrodes) probe equipped with a selective membrane, highly specific for soluble ionic NH_4, differently than the commonly-equipped NH_3-selective membrane. In this way, the measurements taken have been more robust and free from interferences.

Basing on the chemical analysis, we can draw the conclusion that the removal of ammonium from the liquid fraction has been extremely satisfactory with the highest abatement rates reached in TEST 1 (54.4%). The result is valuable if we consider that the SP reaction was conducted in a cement tank rather than in an appropriate specific-designed high-yield crystallizator. It is expected that in this case the NH_4 abatement rates can greatly improve.

The chemical data concerning the solid fraction (O-SEP) showed that the solid precipitate obtained has a remarkable content of nutrients and organic carbon and that it can be regarded as a potential fertilizer bearing characteristics similar to those typical of an organo-mineral fertilizer.

The proximate analysis showed that it is highly likely that a significant quantity of struvite did form upon the SP reaction. Further analysis tackling the crystallographic, spectroscopic, granulometric and thermic characteristics of the precipitate will provide better insights on the content of struvite in the O-SEP and the purity of the material along with other quality-related characteristics.

Likewise, crucial piece of information about the agronomic value of the O-SEP will be given out by the agronomic study.

An update of the preliminary calculation scenario laid down in the SOTAR reveals a sharp improvement of the conditions surrounding the fertigation procedures.

The Butmir's soil requirements for the yearly allocation of nitrogen would be lacking in only three additional hectares with respect to the available surface. When the nitrogen captured in the solid derived from the centrifugation is considered, there would be even and extra surface of more than six Ha. In other words, a thorough solid-liquid separation treatment would be adequate to allow compliance with the Nitrate Directive.

On the other hand, the adoption of SP would result in a further saving in terms of available land for fertigation and the concurrent production of struvite (about 60t/y for a 33% NH_4 abatement rate) would represent a valuable integration to the farm income.

As the system has a huge improvement, potential higher abatement rates can be easily expected and so higher amount of O-SEP can be certainly attained.

Further understanding into the matter can be achieved by an in-depth economic analysis.

Improvement perspectives

A way to improve the performance and effectiveness of the SP process cannot neglect the set- up of the following units:

A crystallizator (FC, FBC, Airlift, etc…) thus letting the cement tank as an equalization-mixer where stripping can take place.

A settler that could favour the separation of O-SEP from the liquor and prompt its thickening.

A pressurized bag dewatering system.

The possible cost of such a technological improvement for a 3 m^3/batch loading rate can supposedly be around 80-100k€. A more accurate estimate can only be made based on a specific design.

Annexes

B&H: the 1st experiment of struvite production conducted 18.11.2020.

Centrate treated volume: **3,3 m³**

Calculated reagent dosing: **H3PO4: 10,5 l; MgCl: 7,6 l**

time	Action /process	reached values on the sensors	
		pH	NH4-N, mg/l
8:30	Starting of aeration		
12:40	Starting of H3PO4 and MgCl dosing	8,20	558
12:55	All amount of MgCl consumed		
13:45	All amount of H3PO4 consumed		
13:46	Starting of NaOH dosing	6,79	563
16:43	Stop of NaOH dosing. **36 l of NaOH used.**	8,55	371
16:43	The aeration is continuing.		
17: 30	The aeration is continuing.	8,77	360
17: 42	Stopping of aeration.	8,80	350
18: 11	The values on the sensors are stabilized. **Transferring of the substrate into filtering bags**	8,86	341

B&H: the 2nd experiment of struvite production conducted 3.12.2020.

Centrate treated volume: **3,0 m^3**

Calculated reagent dosing: **H_3PO_4: 10,8 l; MgCl: 5,2 l**

time	Action /process	reached values on the sensors		
		pH	NH4-N, mg/l	K, mg/l
8:15	Starting of aeration			
11:16	Starting of H3PO4 and MgCl dosing	8,12	446 (lab 502)	680
11:32	All amount of MgCl consumed	7,34	443	680
12:55	All amount of H3PO4 consumed	6,55	373	653
12:55	The aeration is continuing			
13:10	Starting of NaOH dosing	6,55	369	653
14:39	Stop of NaOH dosing. **28,5 l of NaOH used.**	8,84	267	676
14:39	The aeration is continuing.			
15: 20	Stopping of aeration. The values on the sensors are stabilized.	**8,81**	**259**	**679**
15:35	Sampling of centrate + reagents. **Transferring of the substrate into filtering bags**			

B&H: the 3re experiment of struvite production conducted 10.12.2020.

Centrate treated volume: **3,0 m³**

Calculated reagent dosing: **H3PO4: 14,0 l; MgCl: 9,0 l**

time	Action /process	reached values on the sensors		
		pH	NH4-N, mg/l	K, mg/l
9:00	Starting of aeration			
11:38	Starting of H3PO4 and MgCl dosing	8,09	648*	964
12:18	All amount of MgCl consumed	6,58	649	892
13:00	All amount of H3PO4 consumed	6,04	691	890
	The aeration is continuing			
13:15	Starting of NaOH dosing	6,0	685	890
16:58	Stop of NaOH dosing. **46,0 l of NaOH used.**	9,57	349	823
	The aeration is continuing.			
17: 41	Stopping of aeration. The values on the sensors are stabilized.	**9,45**	**371**	**18**
18:15	Sampling of centrate + reagents. **Transferring of the substrate into filtering bags**			

Note

Sampling and testing (analyzing) of centrate for 3rd experiment has been done a day ago (9.12.2020).

During night before setting up the 3rd experiment it was raining so the reaction tank was almost full. So, we had to pourut the liquid and put a new centrate with different characteristics.

The value for NH4-N and pH were real because of we analyzed them, before adding the reagents but other parameters of chemical analyzing were changed.

AGRONOMIC EVALUATION OF B&H PRODUCED STRUVITE

Project co-financed by the European Regional Development Fund

Methodological Protocol

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	**WP-3**
Activity n and title	**3.4 – Agronomic evaluation of the pilot activities**
Deliverable n. and title	**D341 - Methodological Protocol for the agronomic evaluation**
Responsible Partner	**NRD-UNISS**
Participating partners	**Cyprus University of Technology, Fundación Global Nature, Faculty of Agriculture and Food Sciences (UNSA)**
Main authors	**Domenico Ronga**
Reviewers	**Sara Melito**

Project short description

As we all know, the Mediterranean area is a crossroads of different cultures and ethnicities, which however share a distinctive interest in the quality of food, the protection of environmental resources and the defense of traditional products and activities.
Agriculture and livestock farming are two of the key sectors of the Mediterranean economies, there's no doubt about that. And cows and pigs are, for most countries, the most common sources of traditional food. However, due to the ever-increasing demand of quality products, Mediterranean producers have focused more and more on intensive farming to speed up and improve production. This has also led to increased pollution and several other environmental concerns.
Developing and testing innovative technologies which can turn livestock waste into resources is the main goal of RE-LIVE WASTE.
Livestock waste has been (and is) a major source of pollution, but it can now become an opportunity for society and farmers' development.
Project pilot plans will be installed in 4 different countries and transform slurry into an organic high-value commercial fertilizer (also known as struvite), contributing to smart and sustainable growth and to the creation of new business and market opportunities.
RE-LIVE WASTE perfectly matches the 2030 UN Sustainable Development Goals, supporting circular economy as a path towards an innovative, environmentally-friendly, efficient and sustainable future.

Overall objective

To stimulate innovation among public institutions and private companies for a more effective management of waste from intensive livestock farming, by facilitating cooperation between researchers, businesses, public authorities and the civil society

Specific objectives

1. To help farmers use innovative equipment to transform slurry into an eco-friendly fertilizer and reuse it within a circular economy approach
2. To help public institutions draft new regulations to recognize struvite as a fertilizer and provide legislative and financial support to promote the use of innovative effective equipment
3. To improve transnational cooperation and connections between researchers, businesses, public authorities, the civil society and other stakeholders

Agronomic protocol

Baby leaf lettuce (*Lactuca sativa* L.) and radish (*Raphanus sativus* L.) have been selected for the agronomic assessment of the struvite. Baby leaf lettuce and radish will be produced in each country (research group). However, there aren't limitation on the number of species that each research group can assess, obviously adapting the agronomic protocol for the new species that will be considered. Where possible plants will be grown in growth chamber under the following conditions:

1. Light: long-day conditions (15 h light at 25 °C, 9 h dark at 19 °C; light intensity at least 180 µmol m^{-2} s^{-12}).
2. Humidity: relative humidity will be maintained at 65%.

Where growth chamber or phytotron are not available the plants could be produced in greenhouse. The experiment will be set up as a randomized complete block design (RCBD) design with 15 replicates (corresponding to 15 pots (with 20 lettuce seedlings and 1 radish one, each pot, respectively) *per* treatment.

Seeds will be sown manually in a nursery potting soil using commercial neutralized peat[1] (pH ⍰ 6.0 – 7.0), preferably using the same peat in each country. The dimensions of the pots will be ⍰ 100 mm and ⍰ 80 mm (diameter and height, respectively) containing ~ 0.4 L of the growing medium. Finally, to facilitate lettuce and radish germination, a vermiculite layer peat (⍰ 0.5 mm) will be added to all substrates. Each pot will be placed in a pot saucer (however, to optimize the use of space in the growth chambers/greenhouse, pots of the same treatment could be placed in one common pot saucer) and will be manually irrigated every day up to field water capacity. The amount of water used in the irrigations should be recorded to calculate the following physiological parameters. For irrigation the use of tap water is suggested when the available irrigation water shows strange values in term of chemical composition (e.g. pH, electrical conductivity, etc.).

In total, five types of solid substrates will be tested (about the amount of the commercial fertilizer and struvite, we need the chemical analysis of struvite that will be used in the experiment; however, a first/preliminary suggestion is reported below):

1) crop on growing medium without fertilizers

2) crop on growing medium + fertilizer concentrations as similar as possible to treatment 4 (using commercial fertilizer: ENTEC 46 , simple superphosphate, potassium sulphate); however, using the following N-P-K amount: 0.03 g N pot^{-1}, 0.02 g P_2O_5 pot^{-1}, 0.05 g K_2O pot^{-1}

3) crop on growing medium + fertilizer concentrations as similar as possible to treatment 5 (using commercial fertilizer: ENTEC 46[13], simple superphosphate, potassium sulphate); however, using the following N-P-K amount: 0.06 g N pot^{-1}, 0.04 g P_2O_5 pot^{-1}, 0.1 g K_2O pot^{-1}

4) crop on growing medium + struvite at level 1 (lower dose); however, using the following N-P-K amount: 0.03 g N pot^{-1}, 0.02 g P_2O_5 pot^{-1}, 0.05 g K_2O pot^{-1} 5) crop on growing medium + struvite at a level 2 (normal dose); however, using the following N-PK amount: 0.06 g N pot^{-1}, 0.04 g P_2O_5 pot^{-1}, 0.1 g K_2O pot^{-1}

Fertilizers will be added only before the sowing. Growing media pH and EC will be determined on wet material (1:5 ratio) using a pH meter and EC meter, respectively. To evaluate the influence of the different growing media, on crop's germination rate, a phytotoxicity test will be performed. Briefly, 4 mL of each growing media water (using dH_2O) extract (50 g L^{-1}, shacked for 30 min and after filtered with a net mesh ~ 1 mm), plus a control treatment of only water will be added to Petri dishes containing Whatman filter paper. Three

[12] we suggest the following peat: Commercial name Technic. Manufacturer Free Peat, Holland. Composition: 23% organic carbon, 0.5% nitrogen (N). Anyway, each partner can use another peat, however, similar to that suggested in the present protocol.
[13] https://eurochemagro.com/uploads/product/entec-46/3PDS_46-N_ENTEC_5695_GR_Griechenland-englisch.pdf. Anyway, each partner can use another slow-release nitrogen fertilizer, however, like that suggested in the present protocol.

replicates of 20 seeds (for each investigated crop, using baby leaf lettuce and radish obviously in different Petri dishes, in addition *Lepidium sativum* L. also will be assessed) will be prepared, and the plates will be incubated 36 h at 25 °C in a heating chamber at dark condition. After 36 hours, the number of all germinated seeds and the respective roots length will be recorded in order to calculate a Germination Index (GI%) according to the following formula: $GI\% = 100 \times (G_t/G_c) \times (R_t/R_c)$ where,

G_t=number of germinated seeds of the treatment;

G_c=number of germinated seeds of the control;

R_t=average length (mm) of roots of the treatment; R_c=average

length (mm) of roots of the control.

Not required by the protocol, however the amount of nutrient released in each growing media might be assessed during the experiment.

For pot experiment, emergence will be recorded every day. Emergence rate will be calculated as $\Sigma G/t$, where G is the number of seeds emerged and t is the total time of emergence.

At 10, 20, and 30 days after sowing (DAS) the following parameters will be measured (on 5 pots and measuring 3 plants *per* pot on lettuce): stem height (H) and diameter (D), stem height-to-diameter ratio (H/D), number of leaves, and the chlorophyll concentration on the youngest fully expanded leaf using a Minolta SPAD-502 (Minolta, Japan)[14]. When instrument SPAD is not available the chlorophyll concentration will be measured with destructive method on representative samples.

At the end of each crop cycle the following agronomic parameters will be recorded. Before the harvest, plant height (H) will be measured, and chlorophyll content will be estimated by measuring three leaves by using SPAD-502, Minolta (Japan). At least 10 SPAD values *per* treatment need to be assessed. A subsample of each treatment will be used to detect leaf nitrate content. For shoot (SDW), root (RDW, washing away the soil from roots) and total dry weights (TDW) all plants in 5 different pots will be measured after desiccation in stove at 65 °C. Harvest index (HI), fraction of biomass to root (FTR) and SDW/H ratio will be calculated.

Finally, the shelf life of lettuce and radish will be assessed by harvesting fresh shoots and root, respectively, of five pots both for lettuce and radish. Briefly, the samples will be kept for up to 7 days and subsequently will be assessed. Lettuce and radish will be stored (separately) in white transparent boxes (115 mm (width)×97 mm (depth)×30 mm (height)) and stored at 5 °C for 7 days in the dark and at 90% RH. During this time, the fresh weight will be recorded on a daily basis (We may consider more analysis if we will see a possible common submission for publications etc.).

Ash content (dry weight basis) will be measured after 4 h in a muffle furnace at 550°C until constant weight.

If possible, macro and micronutrient will be detected both for growing media and biomass produced.

1. Physical and physicochemical characterization of growing media (pH, EC, organic matter, organic C, particle size, porosity, air filled porosity, water holding capacity, bulk density. Also nutrients (N, K, P, Ca, Mg, Na, Fe, Cu, Zn, Mn).

[14] https://www5.konicaminolta.eu/en/measuring-instruments/products/colour-measurement/chlorophyll-meter/spad502plus/introduction.html

2. Minerals for plant biomass (N, K, P, Ca, Mg, Na, Fe, Cu, Zn, Mn)

If some partners do not have the ability to do same analysis (points 1 and 2), Nikolaos can provide support and do their analysis in Cyprus (of course if it is a "logical'' number of samples and related to the time frame to do the analysis).

Nitrogen content of biomass will be also measured by the Kjeldahl method (AOAC, 1990). Nitrogen use efficiency (NUE), which indicates the total biomass produced *per* unit of N uptake, expressed as the ratio of dry matter production to nitrogen content (g g^{-1}), will be calculated. Crop water productivity (CWP), expressed as the ratio of aboveground dry biomass production at final harvest to water used by the crop (g d. w. L^{-1}), will be calculated.

For the quality analysis of the harvest products we suggest to store the different replicates of each investigated treatment at -20 °C until further processing.

Regarding analysis of chlorophylls, all samples will be shock-frozen in liquid nitrogen and stored at −20 °C until further processing. The leaves of the five seedlings will be weighed, measured to leaf area (in the case that leaf area meter is not available a leaf discs and their relevant fresh weight, performing the correlation to the total plant fresh weight, can be used), pulled and pulverized with mortar and pestle in liquid nitrogen, then transferred into a test tube and extracted three times with 1.5 mL (4.5 mL total) methanol containing $CaCO_3$. Supernatants of the three centrifugations will be grouped and made up to 5 mL. Extinction coefficients of the chlorophylls in pure methanol will be used to calculate the chlorophyll a and b concentration in the extracts (in µg cm^{-2}) using a spectrophotometer.
For total polyphenol (TP) and carotenoid (TC) content characterizations, harvestable organs will be grossly chopped and then homogenised at low speed, under insufflation of a pure nitrogen stream to prevent oxidation. TP content will be analysed using the Folin-Ciocâlteu method. In a 10-mL flask, 0.2 mL of the clear sample (previously centrifuged), 6 mL of water, and 0.5 mL of the Folin-Ciocâlteu reagent will be added. After 1 min of shaking with a vortex, 2 mL of 15% aqueous sodium carbonate will be added and the solution will be made up to 10 mL with water. Finally, this solution will be mixed and left to stand at ambient temperature for 120 min. Absorbance will be read at 700 nm against a blank represented by the reagents only and compared with a standard gallic acid calibration curve. For TC determination, briefly, 1 g of each sample will be weighed into a centrifuge tube and extracted until the residue will be colourless (three extraction cycles) with a mixture consisting of 1 mL hexane, 0.5 mL ethanol, and 0.5 mL acetone (containing 0.05% w/v butylated hydroxytoluene). Samples will be tightly sealed and shaken for 15 min. Afterwards, 0.6 mL of deionised water will be added, the sample will be shaken for another 5 min and left to stand to favour the solvent phase separation. The pooled hexane phases will be made up to 6 mL and finally diluted 1 in 10 (total dilution factor = 60). The absorbance of the upper hexane layer will be read at 450 nm and 471 nm, against a blank of pure hexane. TC (expressed as mg 100 g fresh $weight^{-1}$) will be calculated using the 2500 as the specific extinction coefficient E (1%, 1 cm) at the maximum absorption 450 nm.

Total antioxidant flavonoids (TAF) will be determined by a reaction with $NaNO_2$ and $AlCl_3$ at a basic pH, as described by Zhishen et al. (1999), with catechin used as standard; the product of the reaction being detected spectrophotometrically at 510 nm. This protocol is often claimed to measure 'total flavonoids' in the sample, although this is not strictly true. The method is based on the nitration of aromatic rings containing a catechol group. Several groups of flavonoids e.g. flavanols and flavanols but also other phenolics, such as caffeic acid and derivatives react in this way. Nevertheless, phenolic compounds detected in the assay are all strong antioxidants and there is a good correlation between their levels and the total antioxidant activity of the samples (Zhishen et al. 1999).

MDA malondialdehyde is an excellent marker of oxidative stress that can be quantified from the same extract with phenols and flavonoid.

Fresh plant material will be extracted with 80 % methanol, in a rocker shaker, for 24–48 h. MDA in the extracts is determined using a previously described method (Landi, 2017). Briefly, the samples will be mixed with 0.5 % thiobarbituric acid (TBA) prepared in 20% trichloroacetic acid TCA (or with 20% TCA without TBA for the controls), and then incubated at 95 °C for 20 min. After stopping the reaction on ice, the absorbance of the supernatants will be measured at 532 nm. The non-specific absorbance at 600 and 440 nm will be subtracted, and MDA concentration determined using equations from Landi (2017).

References

Landi, M. (2017). Commentary to:"Improving the thiobarbituric acid-reactive-substances assay for estimating lipid peroxidation in plant tissues containing anthocyanin and other interfering compounds" by Hodges et al., Planta (1999) 207: 604–611. *Planta*, *245*(6), 1067-1067.

Zhishen, J., Mengcheng, T., & Jianming, W. (1999). The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. *Food chemistry*, *64*(4), 555-559.

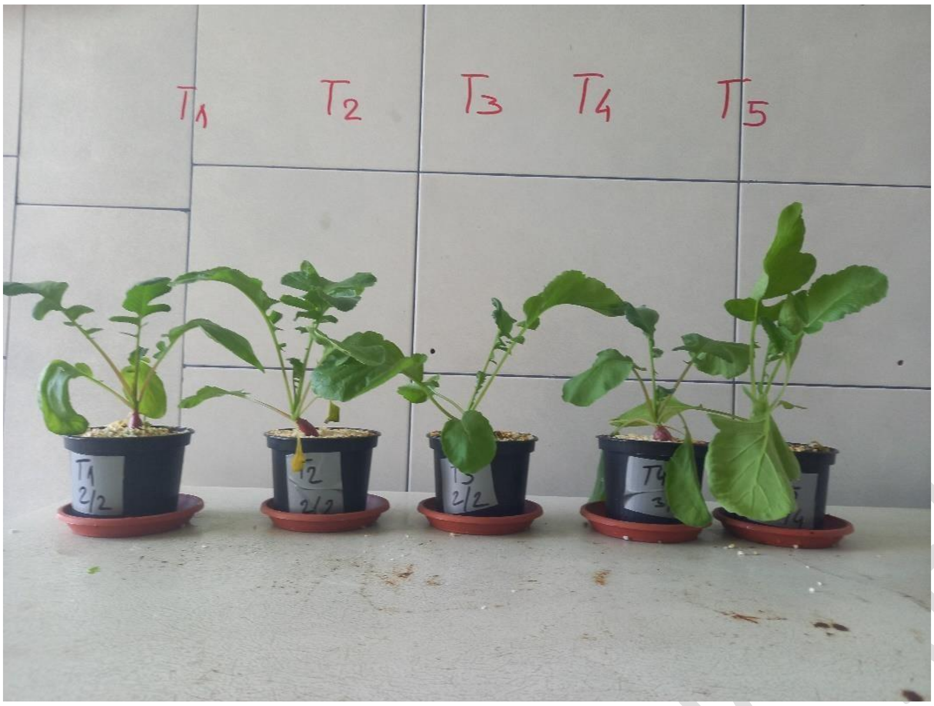
Project co-financed by the European Regional Development Fund

Agronomic Test-Bosnia and Herzegovina

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	**WP-3**
Activity nº and title	**3.4 – Agronomic evaluation of the pilot activities**
Deliverable nº and title	**D341 – Agronomic Evaluation**
Responsible Partner	**UNISS**
Participating partners	**Faculty of agriculture and food sciences, University of Sarajevo**
Main authors	**Senada Čengić-Džomba**
Reviewers	**Emir Džomba**

Photo 1. Lettuce (above) and radish (below) at the end of testing period



Content

Date: Experiment conducted in February/March, 2021.
Site: Experimental fiield of FAFS
Aim: Testing the fertilezers including struvite obtained in B&H pilot plant

Treatments:
Treatment 1: crop on growing medium without fertilization

Treatment 2: crop on growing medium with traditional fertilization using the N-P-K commercial fertilizer; amount: 0.03 g N pot^{-1}, 0.02 g P_2O_5 pot^{-1}, 0.05 g K_2O pot^{-1})

Treatment 3: crop on growing media + fertilizer as similar as possible to treatment 5 (ENTEC 46, simple superphosphate, potassium sulphate);

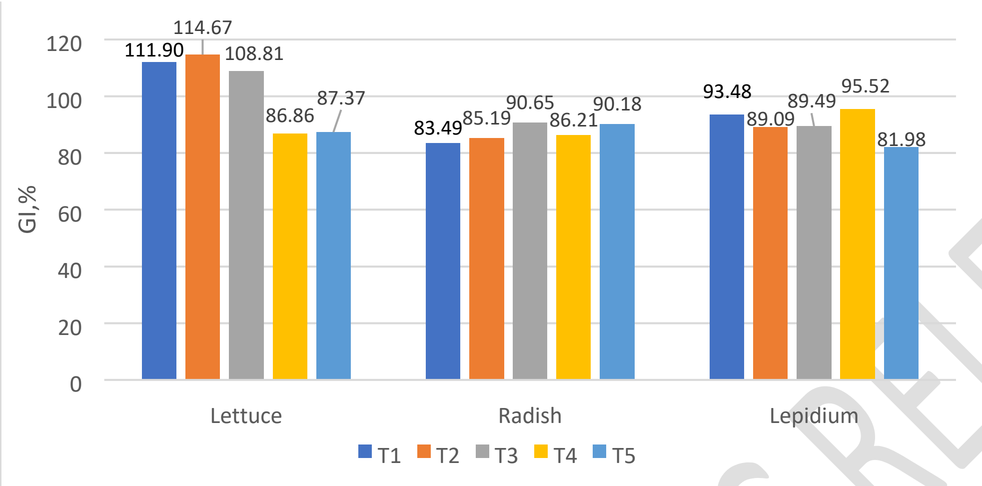
N-P-K amount: 0.06 g N pot^{-1}, 0.04 g P_2O_5 pot^{-1}, 0.1 g K_2O pot^{-1}) **Treatment 4**: crop on growing media + struvite at level 1 (lower dose); same N-P-K amount that Treatment 2

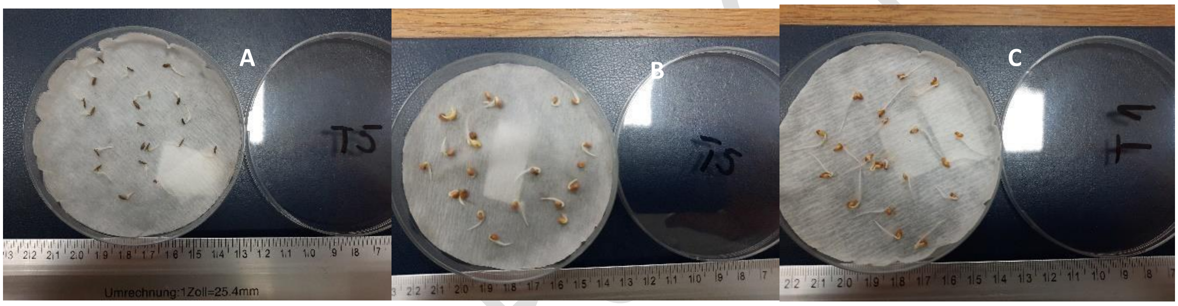
Treatment 5: crop on growing media + struvite at a level 2 (normal dose): same N-P-K amount that Treatment 3

Testing crops: Baby lettuce and radish
Duration: 30 days
Experimental design: CRB

A. Physiological potential of lettuce and radish seeds

Table A1. Germination index of lettuce, radish and Lepidium





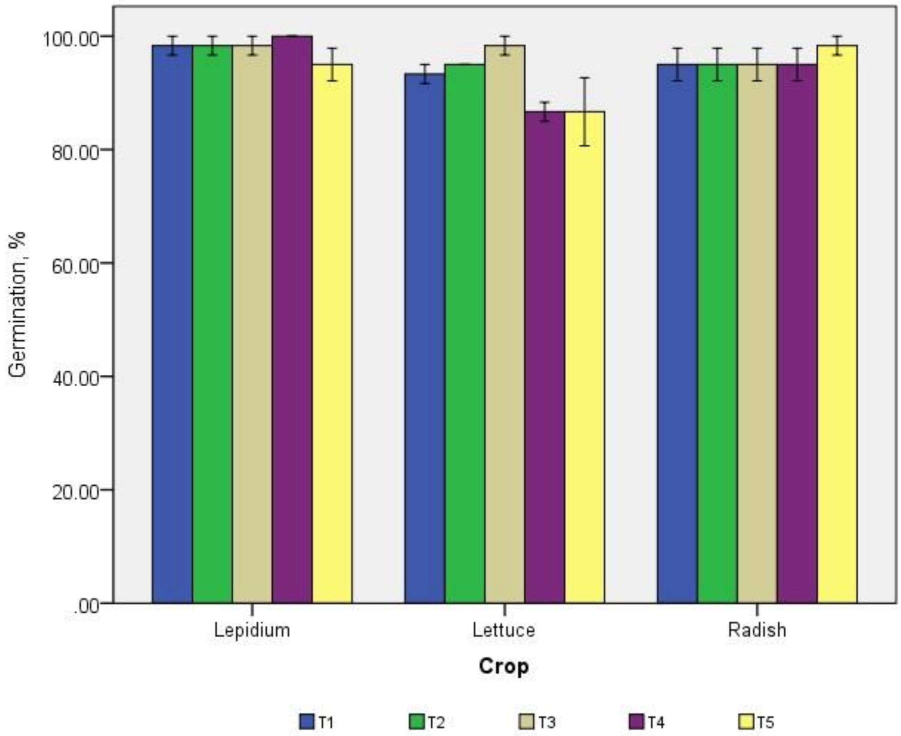
Seed germination of lettuce (A), radish (B) and *Lepidium sativum* (C)

NOTE:

Germination index (GI) was callculated as

$$GI = \frac{Number\ of\ germinated\ seeds\ in\ tested\ treatment}{Number\ of\ germinated\ seeds\ in\ control\ treatment} \ \frac{Length\ of\ germs\ in\ tested\ treatment}{Length\ of\ germs\ in\ control\ treatment}\ x\ x\ 100$$

Table A2. Seed germination (%) of lettuce, radish and lepidium grown on different growing media.



The error bars represent standard error of mean. Differences between tratments in each crop are not significant (p>0,05)

NOTE : Germination percentage (GP) = seeds germinated/total seeds x 100

$$GP = \frac{Germinated\ seeds}{Total\ seeds}\ x\ 100$$

Table A3. Emergence rate of lettuce (mean value±standard deviation)

Treat-ment	Hours after seedling						
	60	72	84	96	108	120	132
T1	38.10±24.31	61.80±24.75	73.50±16.65	80.77±10.54	87.77±6.81	90.97±4.42	93.80±4.44
T2	60.50±14.17	72.23±7.32	81.08±6.58	84.78±7.50	89.73±4.58	90.67±3.65	95.30±0.66
T3	50.10±4.62	62.10±7.03	75.90±12.42	86.40±9.35	90.93±3.20	93.93±0.98	95.83±1.07
T4	55.47±12.27	74.00±9.01	83.33±8.24	90.60±3.59	92.60±2.15	93.67±2.87	96.13±0.42
T5	67.80±15.44	83.97±9.69	88.60±9.80	92.30±5.14	94.23±3.69	94.23±3.69	96.23±0.49

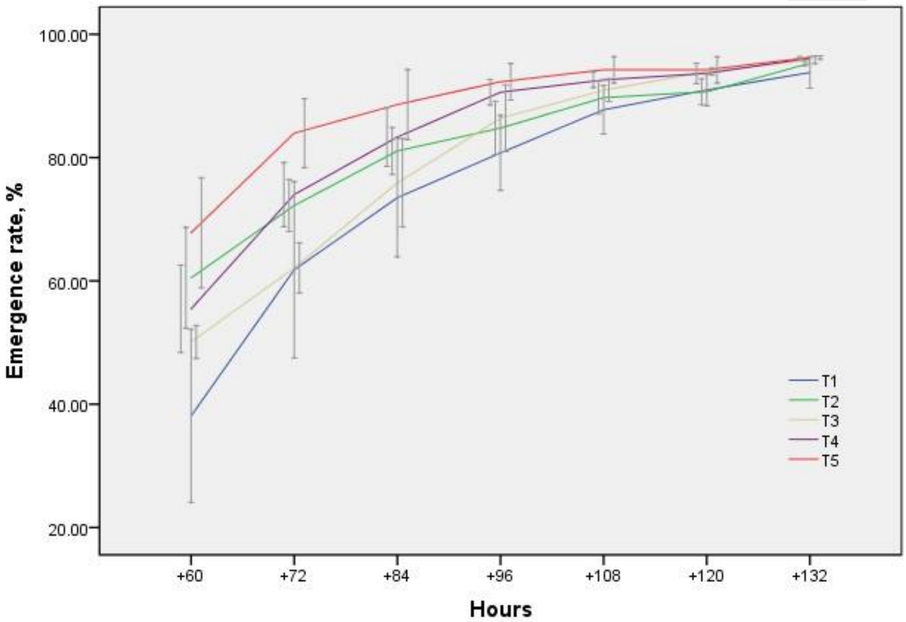


Figure A1. Emergence rate of lettuce grown od different growing media. The bars represent standard error of mean.

Final emergency rate of letuce was similar between tretaments but treatments T5 and T4 (GM with addded struvite) have tendency to reach platou much earlier than other treatrments.

Table A4. Emergence rate of radish (mean value±standard deviation)

Treat.	Hours after seedling							
	60	72	84	96	108	120	132	144
T1	40.00±0.00	53.33±11.55	60.00±20.00	66.67±23.09	73.33±11.55	73.33±11.55	80.00±0.00	80.00±0.00
T2	33.33±30.55	46.67±41.63	60.00±34.64	60.00±34.64	73.33±11.55	73.33±11.55	80.00±0.00	80.00±0.00
T3	46.67±50.33	93.33±11.55	93.33±11.55	93.33±11.55	93.33±11.55	93.33±11.55	93.33±11.55	93.33±11.55
T4	53.33±30.55	73.33±30.55	80.00±20.00	80.00±20.00	86.67±11.55	86.67±11.55	86.67±11.55	86.67±11.55
T5	66.67±23.09	73.33±11.55	80.00±0.00	86.67±11.55	86.67±11.55	86.67±11.55	86.67±11.55	86.67±11.55

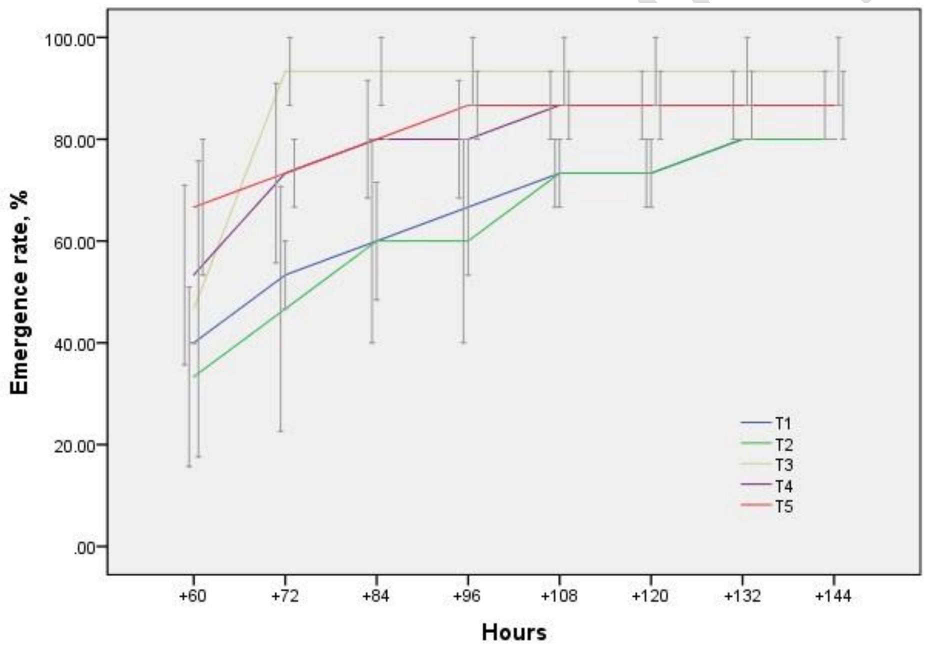


Figure A2 . Emergence rate of radish grown od different growing media. The bars represent standard error of mean.

Similarly to lettuce, radish shown better emergency rate of treatments with added struvite. Although statistical test had not done, final emergency rate of radish was higher in tretaments T4 and T5 comparing to T1 and T2 treatments.

B. Water productivity

Table B1. Amount of water used for crop irrigation and water productivity (WP) expressed on total dry mass and fresh weight basis (mean value±standard error of mean)

Treatment	Used water, L pot^{-1}		WP, g DW L^{-1}		WP, g FW L^{-1}	
	Lettuce	Radish	Lettuce	Radish	Lettuce	Radish
T1	1.10±0.10^{c}	0.89±0.01	1.05±0.06^{b}	0.79±0.12^{ab}	26.20±1.56	14.92±2.52
T2	1.18±0.02c^{b}	0.89±0.02	1.38±0.03^{a}	0.84±0.07^{ab}	27.62±0.57	13.94±0.48
T3	1.50±0.03^{a}	0.88±0.01	1.26±0.05^{a}	0.95±0.10^{ab}	27.60±1.06	18.51±1.70
T4	1.33±0.06^{ac}	0.90±0.01	1.38±0.02^{a}	0.63±0.08^{a}	27.52±0.37	13.80±0.93
T5	1.45±0.03^{a}	0.88±0.01	1.27±0.03^{a}	1.10±0.07^{b}	28.41±0.70	19.95±1.35
p	0.002	0.933	0.002	0.042	0.604	0.058

Water productivity (WP), defined as produced dry biomass per unit of added water for irrigation is similar between treatments with added fertilazers (lettuce) and higher of T5 comparing all other tretments for radish.

C. Physical/morphological characteristics

Table C1. Physical characteristics of lettuce (mean value±standard error of mean)

Treatment	SDW	RDW	TDW	RMR	SDW/H	HI
T1	1.056±0.098^{a}	0.036±0.007^{a}	1.092±0.098^{a}	0.032±0.005^{a}	0.030±0.003^{a}	96.78±0.54^{a}
T2	1.68±0.044^{b}	0.034±0.002^{a}	1.714±0.044^{b}	0.020±0.001^{b}	0.045±0.001^{b}	97.99±0.10^{b}
T3	1.844±0.139^{b}	0.052±0.002^{b}	1.896±0.139^{b}	0.028±0.002^{ab}	0.046±0.003^{b}	97.18±0.00^{ab}
T4	1.888±0.058^{b}	0.046±0.002^{ab}	1.938±0.058^{b}	0.024±0.000^{ab}	0.049±0.002^{b}	97.60±0.05^{ab}
T5	1.784±0.032^{b}	0.042±0.002^{ab}	1.824±0.032^{b}	0.023±0.000^{ab}	0.049±0.004^{b}	97.72±0.04^{ab}
p	0.000	0.014	0.000	0.034	0.001	0.032

SDW=shoots dry weight; RDW = root dry weight; TDW = total dry weight; RMR = root mass ratio (DWR/TDW); SDW/H = shoots dry weight/height ratio; HI = harvest index

Generally, all parameters are higher in treatments with added commercial fertilizers.

Table C2. Physical characteristics of radish (mean value±standard error of mean)

Treatment	SDW	RDW	TDW	RMR	SDW/H	HI
T1	0.681±0.095^{ab}	0.016±0.004	0.697±0.099^{ab}	0.022±0.004	0.014±0.002	2.24±0.25
T2	0.711±0.053^{ab}	0.024±0.000	0.735±0.053^{ab}	0.024±0.000	0.014±0.001	3.30±0.22
T3	0.817±0.083^{ab}	0.024±0.007	0.841±0.080^{ab}	0.024±0.007	0.017±0.003	2.95±0.87
T4	0.552±0.068^{b}	0.016±0.004	0.568±0.072^{b}	0.016±0.004	0.011±0.002	2.74±0.32
T5	0.937±0.075^{a}	0.032±0.004	0.969±0.071^{a}	0.032±0.004	0.019±0.001	3.39±0.062
p	0.044	0.126	0.036	0.551	0.054	0.551

SDW=shoots dry weight; RDW = root dry weight; TDW = total dry weight; RMR = root mass ratio (DWR/TDW), SDW/H = shoots dry weight/height ratio; HI = harvest index

SDW, RDW and TDW of radish are higher in treatments with added commercial fertilizer. T5 tretament have tendency to be superior over other treatments (nonstatistical differences between tretaments with added fertilizers have been caused by relative high variation within group - relative high SE).

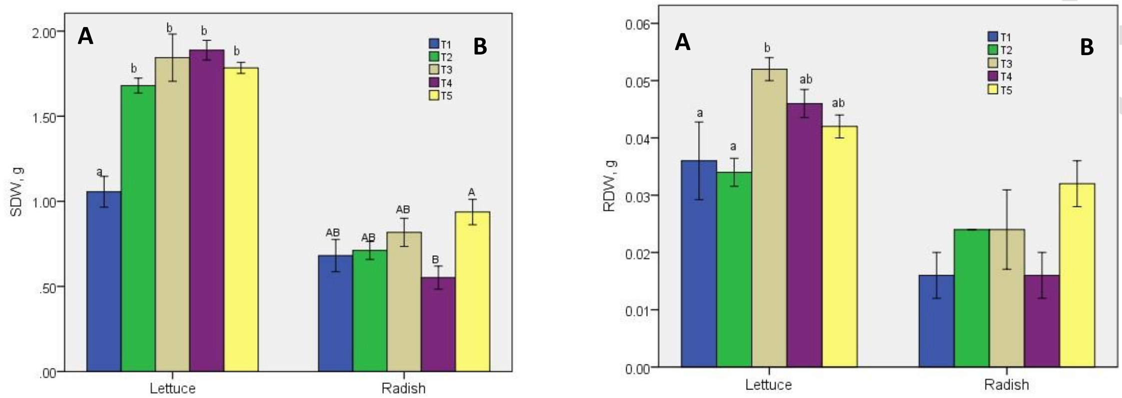


Figure C1. Shoot and root dry weight (SDW), g of lettuce (A) and radish (B) grown on different growing media. The error bars represent standard error of mean.

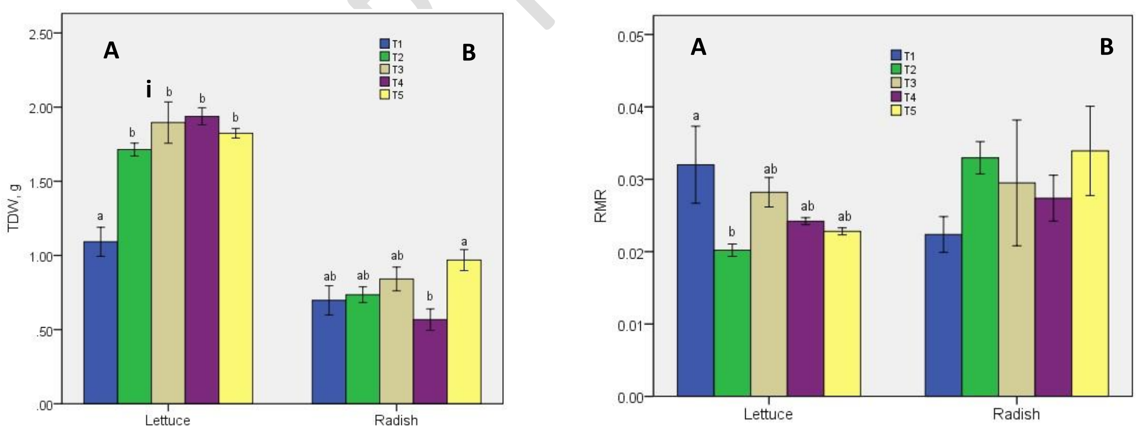


Figure 2. Total dry weight (TDW), g and root mass ratio (RMR) of lettuce (A) and radish (B) grown on different growing media. The error bars represent standard error of mean.

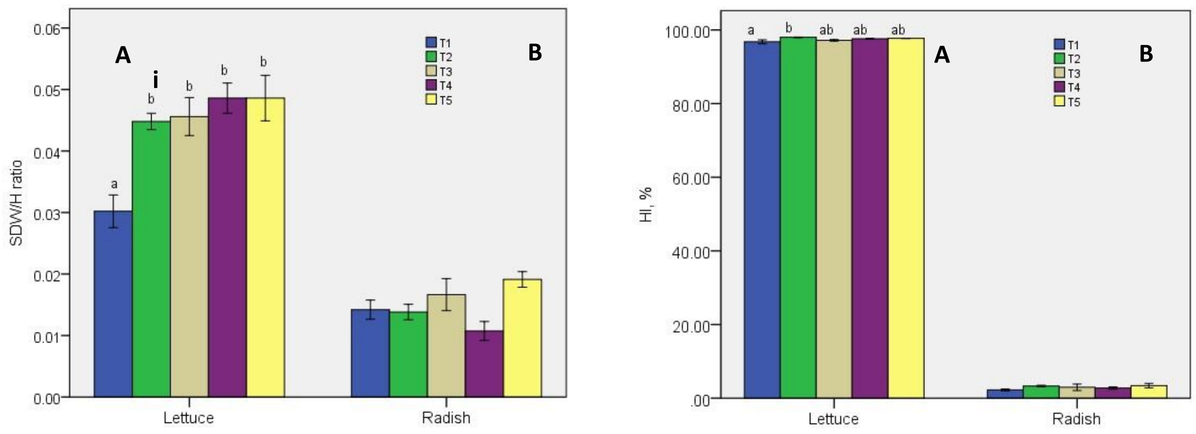


Figure C3. Shoot dry weight/height ratio (SDW/H)) and harvest indeks (%) of lettuce (A) and radish (B) grown on different growing media. The error bars represent standard error of mean.

Table C3. Morphological characteristics of radish after 30 day growing period

Treatment	SH (mm)	SD (mm)	H/D	NoL
T1	48.60±1.03	1.34±0.02	36.30±0.82	5.60±0.24
T2	50.60±1.17	1.42±0.04	35.67±0.63	5.80±0.37
T3	50.40±1.63	1.39±0.02	36.24±0.79	5.80±0.20
T4	50.20±1.28	1.43±0.02	35.10±0.63	5.60±0.24
T5	49.40±1.17	1.40±0.03	35.28±0.26	5.80±0.20
p	0.788	0.230	0.614	0.948

SH – stem height; SD – stem diametar; H/D – height/diametar ratio ; NoL – number of leaves

Table C4. Morphological characteristics of lettuce during growth

treatment	10th day				20th day				30th day			
	PH	SD	H/D	NoL	PH	SD	H/D	NoL	PH	SD	H/D	NoL
T1	36.34±1.25	0.56±0.02^{a}	67.39±4.03	1.92±0.15	111.20±2.96^{a}	2.32±0.12	47.95±1.66	3.56±0.18	182.84±6.37	2.72±0.07^{ab}	67.40±2.61^{b}	5.00±0.32
T2	37.63±0.85	0.68±0.02^{b}	55.80±2.15	2.00±0.20	130.40±3.69^{b}	2.27±0.23	59.27±6.74	3.89±0.20	162.97±7.96	2.69±0.09^{b}	60.62±2.07^{b}	4.60±0.24
T3	37.54±1.31	0.64±0.03^{b}	60.98±4.19	2.07±0.18	128.08±6.82^{b}	2.18±0.06	58.66±1.81	3.89±0.20	156.33±7.53	2.56±0.12^{b}	61.43±3.82^{b}	4.60±0.40
T4	40.46±1.46	0.65±0.02^{b}	63.19±3.11	1.87±0.13	125.31±3.04^{ab}	2.05±0.11	61.44±1.95	3.88±0.13	184.26±9.86	2.44±0.12^{b}	75.49±2.37^{a}	4.60±0.24
T5	39.18±2.28	0.63±0.03^{b}	65.46±5.69	2.07±0.12	133.01±3.61^{b}	2.19±0.15	61.68±4.77	4.00±0.17	178.51±9.28	3.11±0.13^{a}	57.40±2.27^{b}	5.00±0.32
p	0.348	0.032	0.335	0.863	0.006	0.692	0.082	0.470	0.094	0.005	0.001	0.736

^{a,b,c} Values in same colon with different letters in subscript differ at significant level of $p<0.05$ (Tukey test)

PH = Plant height; SD = Stem diametar; H/D = Height/diametar ratio; NoL = number of leaves

D. Mineral content

Table D1. Mineral content in fresh biomass of lettuce (mg/100g) grown in different growing media. Values are expressed as mean of n=3 with standard error of mean.

Treatment	Cu	Zn	Mn	Fe	K	Ca	Mg	P
T1	0.094±0.002	0.280±0.006	0.890±0.029	0.328±0.017	108.11±6.75^{a}	99.55±7.73^{b}	15.55±1.46	16.70±0.29^{b}
T2	0.102±0.008	0.319±0.024	0.965±0.074	0.361±0.012	147.73±5.96^{c}	118.12±2.43^{ab}	17.42±0.60	19.46±0.08^{a}
T3	0.085±0.007	0.319±0.034	0.885±0.077	0.345±0.032	125.62±3.80^{b}	129.85±2.69^{a}	17.30±1.15	19.83±0.32^{ac}
T4	0.082±0.002	0.354±0.023	1.022±0.046	0.365±0.002	138.61±5.96^{bc}	120.37±6.96^{ab}	17.84±0.85	21.87±0.99^{ac}
T5	0.079±0.004	0.331±0.020	0.884±0.106	0.302±0.009	139.29±3.71^{bc}	119.61±7.52^{ab}	17.86±0.34	21.89±0.21^{c}
p	0.104	0.344	0.600	0.067	0.001	0.030	0.109	0.000

^{a,b,c} Values in same colon with different letter in subscript differ at significant level of $p<0.05$ (Tukey test)

Table D2. Mineral content in fresh biomass of radish (mg/100g) grown in different growing media. Values are expressed as mean of n=3 with standard error of mean.

Treatment	Cu	Zn	Mn	Fe	K	Ca	Mg	P
T1	0.107±0.000^{b}	0.497±0.016^{bc}	0.662±0.014^{c}	0.422±0.019^{a}	164.70±3.73	248.43±10.94	26.01±0.77	22.08±0.71^{b}
T2	0.118±0.004^{ab}	0.506±0.026^{bc}	0.613±0.030^{c}	0.418±0.001^{a}	195.85±0.260	245.34±8.68	28.04±0.38	24.89±1.47^{b}
T3	0.152±0.000^{a}	0.626±0.002^{a}	0.870±0.023^{a}	0.652±0.022^{b}	191.54±11.22	280.56±4.88	27.79±0.66	26.02±0.64^{ab}
T4	0.127±0.003^{ab}	0.562±0.014^{ac}	0.720±0.038^{bc}	0.485±0.032^{a}	127.41±55.46	292.06±41.90	27.83±1.36	26.07±1.59^{ab}
T5	0.139±0.017^{ab}	0.607±0.024^{a}	0.871±0.066^{a}	0.574±0.057^{ab}	177.80±10.34	313.25±41.33	28.08±1.50	29.85±1.77^{a}
p	0.025	0.003	0.000	0.004	0.465	0.382	0.615	0.006

^{a,b,c} Values in same colon with different letter in subscript differ at significant level of $p<0.05$ (Tukey test)

Table D3. Crude ash (Ash, % of dry matter) content in biomass of lettuce and radish

	Lettuce	Radish
T1	18.52±0.56[d]	20.97±1.36
T3	21.95±1.30[ac]	24.82±2.15
T3	21.16±1.14[bc]	21.38±0.20
T4	19.93±0.97[b]	22.59±0.09
T5	22.45±0.65[a]	21.81±0.61
p	0.001	0.214

[a,b,c,d] Values in same colon with different letter in subscript differ at significant level of $p<0.05$ (Tukey test)

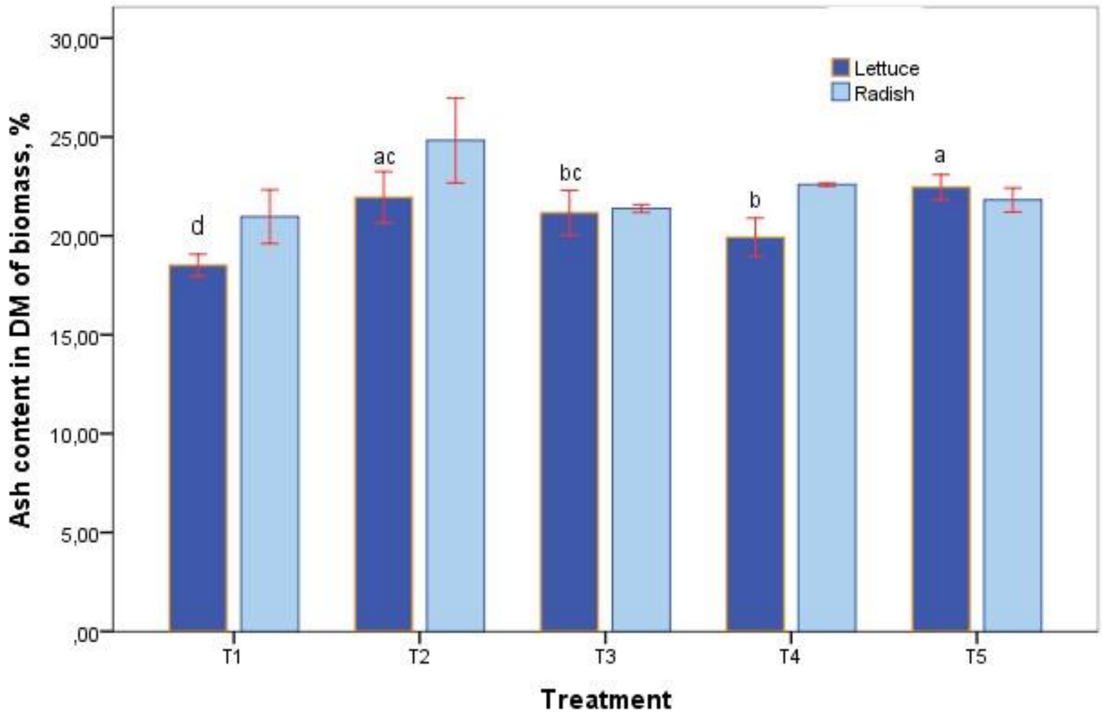


Figure D1. Ash content in biomass of lettuce and radish grown in different growing media. Error bars represent ± one standard error of menas. Bars with different letters differ at level of $p<0.05$ (Tukey test). Effect of tretments on crude ash content in biomass of radish is not significant ($p=0.214$)

Table D4. Nitrogen using efficiency (NUE) in lettuce and radish growing. Values represent mean and standard error of mean calculated on dry matter basis.

	NUE, g g^{-1}	
TREATMENT	Lettuce	Radish
T2	20.83±1..48^{c}	1.04±1.76^{b}
T3	13.11±2.32^{b}	6.80±1.09a^{b}
T4	27.83±1.81^{a}	0.43±1.51^{b}
T5	12.13±0.54^{b}	9.23±2.05^{a}
p	0.000	0.017
Planned comparisson		
T4 vs. T2	0.038	0.922
T5 vs. T3	0.970	0.694

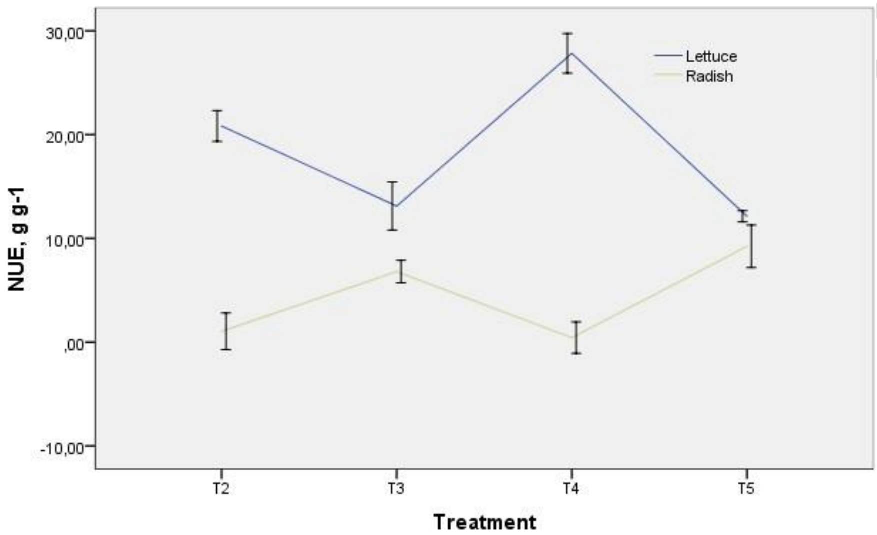


Figure D2. Nitrogen using efficiency(NUE calculated of applied N represents the kg of yield increase per kg of applied N: NUE=(YF–Y0)/NF, where:

-YF is the crop yield obtained with the application of a determinate N-fertiliser (NF) rate; -Y0 is the crop yield obtained in the unfertilised control.

Nitrogen use efficiency were calculated on dry weight basis.

Table D5. Nitrogen and carbon concentration of lettuce shoots cultivated at different growing media (mean±SE)

	N, mg g^{-1} DM	C, mg g^{-1} DM	C/N ratio	Nitrates, mg kg^{-1} FW
T1	35.73±1.39	398.15±2.73^{a}	11.18±0.49^{b}	117.33±5.87^{b}
T2	37.03±1.77	381.35±6.34^{c}	10.36±0.65^{ab}	146.67±11.73^{ab}
T3	37.53±1.47	385.23±5.56^{bc}	10.31±0.54^{ab}	146.67±11.73^{ab}
T4	36.50±1.91	391.24±4.76^{ab}	10.79±0.65^{ab}	168.67±7.33^{a}
T5	38.50±0.93	378.91±3.16^{c}	9.86±0.29^{a}	176.00±10.16^{a}
p	0.146	0.001	0.031	0.002

^{a,b} Values in same colon with different letter in subscript differ at significant level of $p<0.05$ (Tukey test)

Table D6. Nitrogen and carbon concentration of radish shoots cultivated at different growing media (mean±SE)

	N, mg g^{-1} DM	C, mg g^{-1} DM	C/N ratio	Nitrates, mg kg^{-1} FW
T1	42.43±3.02	386.16±6.64	9.22±0.84	92.23±2.68^{b}
T2	45.23±5.60	367.33±10.51	8.41±1.20	110.30±3.20^{bc}
T3	47.63±4.11	384.15±0.99	8.18±0.68	125.03±4.06^{ac}
T4	51.33±2.77	378.24±0.43	7.41±0.42	136.33±5.21^{a}
T5	50.83±2.26	382.04±2.97	7.55±0.41	145.23±6.70^{a}
p	0.517	0.214	0.535	0.000

^{a,b,c} Values in same colon with different letter in subscript differ at significant level of $p<0.05$ (Tukey test)

E. Shelf life

Table E1. Accumulated fresh weight loss of radish shoots (%). Values are expressed as mean±SD.

Treatment	Hours	Lettuce shoots	Radish shoots
T1	0	0.00±0.00	0.00±0.0
	+24	0.11±0.06	0.22±0.10
	+48	1.12±0.65	0.58±0.29
	+72	1.53±0.52	0.66±0.18
	+96	2.67±1.03	0.94±0.05
	+120	3.23±0.98	1.14±0.33
	+144	3.62±0.90	1.26±0.29
	+168	4.17±0.92	1.44±0.32

T2	0	0.00±0.00	0.00±0.00
	+24	0.14±0.04	0.31±0.03
	+48	0.64±0.15	0.86±0.13
	+72	1.18±0.35	1.62±0.12
	+96	1.84±0.59	1.81±0.39
	+120	2.31±0.68	1.85±0.46
	+144	2.64±0.91	2.12±0.21
	+168	3.16±1.18	2.66±0.52
T3	0	0.00±0.00	0.00±0.00
	+24	0.10±0.08	0.38±0.13
	+48	0.90±0.25	0.68±0.01
	+72	1.31±0.16	1.20±0.33
	+96	2.07±0.25	1.79±0.23
	+120	2.58±0.44	1.93±0.43
	+144	3.13±0.35	2.51±0.30
	+168	3.60±0.56	3.62±0.93
T4	0	0.00±0.00	0.00±0.00
	+24	0.17±0.12	0.29±0.12
	+48	0.61±0.34	0.49±0.11
	+72	0.93±0.62	1.57±0.34
	+96	1.43±0.69	1.82±0.26
	+120	1.70±0.68	2.35±1.00
	+144	1.83±0.77	2.74±1.12
	+168	2.21±0.84	2.84±1.25
T5	0	0.00±0.00	0.00±0.00
	+24	0.14±0.04	0.22±0.09
	+48	0.33±0.10	0.57±0.26
	+72	0.61±0.17	1.23±0.54
	+96	1.12±0.45	1.59±0.29
	+120	1.46±0.47	1.59±0.29
	+144	1.84±0.67	2.03±0.48
	+168	2.24±0.76	1.99±1.07

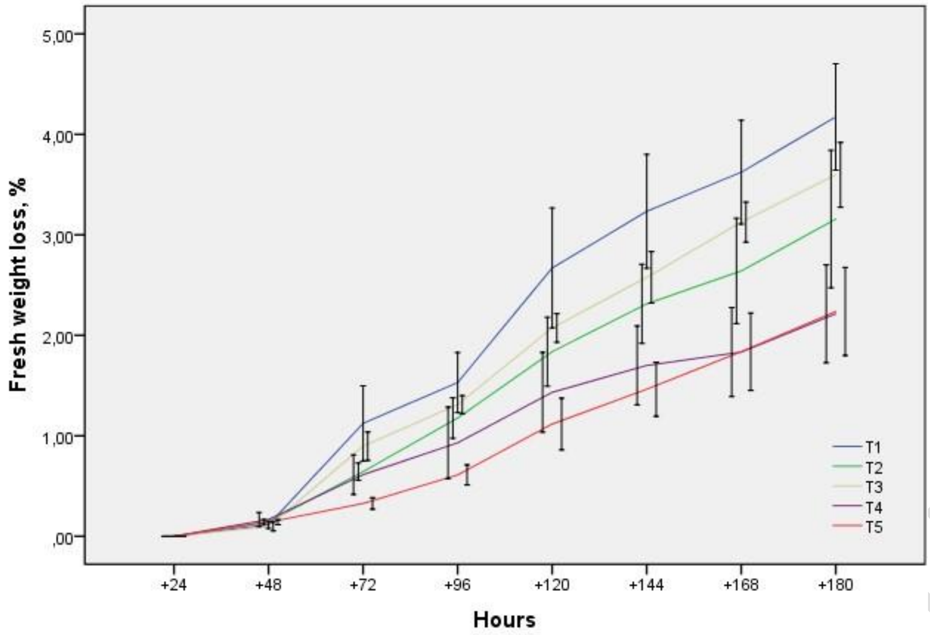


Figure E1. Accumulated fresh weight loss of lettuce shoots. Error bars represent one standard error of mean (SE)

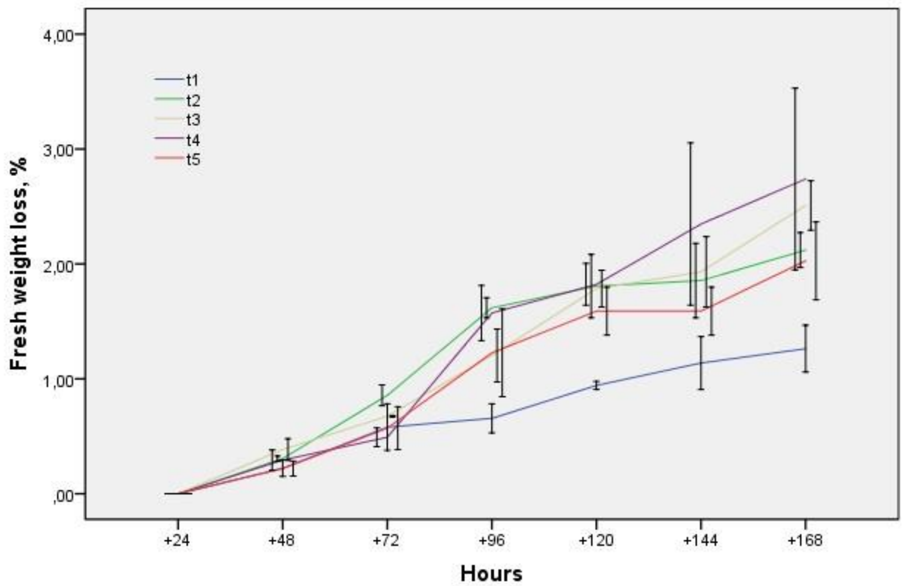


Figure E2. Accumulated fresh weight loss of radish shoots. Error bars represent one standard error of mean (SE)

F. Biochemical characterization of lettuce and radish

Table F1. Chlorophyll content in lettuce leaves at different stage of growing, mg/100 g of FW

Treatment	10th day		20th day		30th day	
	Chlo A	Chlo B	Chlo A	Chlo B	Chlo A	Chlo B
T1	18.30±0.42	10.44±1.01	23.17±2.39	13.05±3.69	26.70±4.01	7.83±1.34
T2	17.05±0.23	12.17±0.15	25.16±2.17	16.94±2.05	23.46±0.85	6.66±0.52
T3	17.57±1.60	10.65±0.41	30.22±1.84	20.59±3.68	22.43±1.81	7.08±0.22
T4	20.60±0.41	9.84±0.88	30.44±4.18	14.46±1.66	24.38±2.26	7.01±0.52
T5	20.22±0.68	9.59±0.48	25.68±2.54	10.19±2.02	28.87±1.31	8.40±0.34
p	0.053	0.128	0.305	0.165	0.347	0.453

Table F2. Total carotenoids (TC), total phenolic (TPC), total flavonoids (TF) and malondialdehide (MDA) content in leaves of lettuce after 30 days

Treatment	TC, mg 100 g^{-1}	TPC, mg g^{-1}	TF, mg eq. GA g^{-1}	MDA, nmol g^{-1}
T1	7.49±0.72^{a}	0.46±0.01	0.18±0.03^{b}	20.50±1.75^{b}
T2	5.67±0.25^{ab}	0.47±0.06	0.15±0.01^{b}	14.67±1.52^{bc}
T3	5.26±0.49^{b}	0.52±0.02	0.30±0.03^{ab}	15.58±0.65^{bc}
T4	5.59±0.47^{ab}	0.59±0.04	0.38±0.71^{a}	13.5±1.81^{ac}
T5	7.26±0.41^{ab}	0.55±0.08	0.19±0.03^{b}	7.92±1.17^{a}
p	0.025	0.340	0.009	0.002

Table F3. Biochemical characterization of radish shoot after 30 days growing period

Treatment	Chlo A	Chlo B	TC, mg 100 g^{-1}	TPC, mg g^{-1}	TF, mg eq. GA g^{-1}	MDA, nmol g^{-1}
T1	118.81±8.45^{a}	38.30±3.72^{ab}	26.85±3.04^{a}	1.32±0.06^{a}	0.31±0.02	0.06±0.03^{b}
T2	101.44±6.15^{ac}	45.52±5.30^{a}	19.44±0.99^{ab}	1.17±0.03^{ab}	0.32±0.03	0.85±0.75^{b}
T3	114.28±4.51^{a}	47.53±0.70^{a}	19.30±1.99^{ab}	1.07±0.03^{bc}	0.30±0.03	7.28±1.31^{a}
T4	69.81±4.96^{b}	30.20±1.80^{b}	13.52±0.83^{b}	0.98±0.03^{c}	0.23±0.02	8.93±1.15^{a}
T5	82.77±2.70^{bc}	31.46±1.12^{b}	17.97±0.52^{b}	0.64±0.05^{d}	0.24±0.02	2.73±0.72^{b}
p	0.000	0.007	0.004	0.000	0.096	0.000

G. Substrate analysis

Table G1. Particle size of different growing media used for lettuce and radish growing

Species	Treatment	8 mm	4 mm	2 mm	1 mm	0.6 mm	0.18 mm	<0.18 mm
Lettuce	T1	0.00	3.89	14.07	17.52	16.46	40.13	7.93
	T2	0.00	2.40	11.80	16.73	16.00	42.13	10.93
	T3	0.00	2.47	14.48	20.40	19.66	37.21	5.78
	T4	0.00	5.08	13.63	18.55	17.68	36.55	8.51
	T5	0.00	3.49	13.33	17.99	19.65	37.91	7.63
Radish	T1	0.00	5.47	16.00	20.01	18.57	32.15	7.81
	T2	0.00	5.91	15.71	19.42	17.31	33.64	8.01
	T3	0 .00	3.20	15.80	20.60	18.90	35.50	6.10
	T4	0.00	2.90	17.70	21.00	19.00	32.00	7.40
	T5	0.00	3.80	16.84	18.94	21.14	33.17	6.11

Particle size (%) was performed by dry sieving air dried samples in vibrating sieve

Table G2. Chemical, physical and water-physical characteristics of substrate

Species	Treatment	pH H_2O	pH 1M KCl	Bulk Density BD (g/cm^3)	Spec. gravity Sg/Particle Density (g/cm^3)	Porosity P (%$_{vol}$)	Water Holding Capacity (%$_{vol}$)	Air Capacity (%$_{vol}$)
Lettuce	T1	5.90	5.58	0.151	1.680	90.988	66.915	24.073
	T2	6.00	5.36	0.161	1.691	90.455	64.830	25.625
	T3	5.90	5.41	0.187	1.702	88.965	65.385	23.580
	T4	6.00	5.51	0.144	1.913	92.421	64.645	27.776
	T5	6.10	5.49	0.138	1.706	91.874	60.130	31.744
Radish	T1	5.90	5.45	0.158	1.824	91.314	67.450	23.864
	T2	6.00	5.45	0.149	1.621	90.784	67.355	23.429
	T3	5.80	5.30	0.145	1.987	92.696	63.520	29.176
	T4	6.10	5.55	0.156	1.695	90.780	64.785	25.995
	T5	6.00	5.30	0.158	1.812	91.243	63.300	27.943

The pH value of the substrate (3g) was determined electrometrically in water suspension (50ml). The preparation was taken from ASTM 2976-71, 1990.

ASTM Standard D 4531-86, reapproved 2002, was used as the Standard Test Method for Bulk Density (BD). Bulk density (BD) - the mass of dried substrate (Ms) dried in the oven at 105^{o}C per unit of total substrate volume (V) defined by the volume of the sampling cylinder (100 cm^3); is calculated according to the formula: BD = Ms / V (g /cm^3).

The specific gravity Sg, was made according to the mass of dried substrate at 105 ^{o}C (Ms) in relation to the volume of the same dried substrate (Vs). The volume of dried substrate was measured using the standard air pycnometer method.

Porosity (P) is calculated by the formula P = ((Sg - BD) x 100) / Sg.

As a standard method for moisture, of peat and other organic soils. ASTM Standards D 2974-87, 1990 was used. Method for determining moisture of peat dried in the oven at 110 ± 5 ^{o}C (Ms), according to the formula: ws = ((M - Ms) · 100) / V (%), where M is mass of the wet substrate and Ms is mass of the substrate dried in the oven at 105^{o}C, V the volume of the sampling cylinder (100 cm^3), M as a Water holding capacity is determined by capillary wetting in the cylinder by Gračanin (Water Retention Capacity).

Air capacity represents the difference between Porosity and Water Holding Capacity (%vol).

Table G3. Chemical characteristics of substrate (growing media)

Treatment	Dry matter, %	Organic Matter (% of DM	Ash (% of DM)	N Total,(%)	P Total, (%)	Organic C, (%)
T1	48.81	94.93	5.07	0.5	0.022	24.34
T2	49.60	94.60	5.40	0.53	0.024	24.65
T3	45.80	94.97	5.03	0.54	0.027	22.85
T4	55.79	94.40	5.60	0.56	0.031	27.67
T5	54.57	94.94	5.06	0.55	0.035	27.22

Table G4. Mineral content in growing media, mg/kg DM

Treatment	Cu	Zn	Mn	Fe	K	Ca	Mg
T1	24.33	24.78	44.87	630.46	1441.82	32089.73	2267.52
T2	28.18	28.95	53.17	634.48	1511.04	31403.91	2082.07
T3	27.73	24.69	50.13	623.09	1883.08	31726.42	2028.58
T4	25.59	24.31	50.34	613.46	1810.01	34992.32	2578.04
T5	27.27	26.94	51.92	602.60	2248.45	32412.24	2535.73

Concluding remarks

1. Although added struvite resulted in slightly lower phytotoxicity of substrates as well as seed germination, treatments with struvite had better emergence rate of both lettuce and radish with tendency to reach plateau much earlier comparing to control treatment and treatments with commercial fertilizers.
2. Water productivity (WP) expressed on total dry mass was better in all treatments including ones with struvite comparing to control treatment.
3. Treatments with added struvite resulted in better shoots dry weight, root dry weight, total dry weight, root mass ratio and shoots dry weight/height ratio of lettuce in comparison with control treatment. Among treatments with added fertilizers (T2-T5) differences were negligible.
4. Added struvite have tendency to increase potassium and phosphorus content in biomass of lettuce. Mineral content of biomass of radish were similar between all treatments containing fertilizer (including struvite) but generally higher in comparison to control treatment. Total ash content in biomass of lettuce grown on higher level of struvite was better in comparison to other treatments.
5. Comparison of nitrogen using efficiency (NUE) is reasonable between treatments with same level abut different sources of nitrogen. T4 treatment used in lettuce growing resulted in better NUE in comparison to T2 treatment.
6. Treatment with added struvite resulted in better shelf life (lower fresh weight loss) of both lettuce and radish shoot.
7. The contents of chlorophyll is important physiological parameters in the development of plant growth. In this study, no significant differences among of treatments in lettuce chlorophyll were observed although treatments with struvite decreased chlorophyll concentrations in leaves of radish.
8. Although all used substrates had similar physical and water-physical characteristics, substrates contained struvite contained higher organic carbon, total phosphorus and total potassium in comparison to comparable growing media contained similar amounts of nutrients from commercial fertilizers (T5 vs. T3 and T4 vs. T2).
9.

Generally, growing lettuce and radish on growing media contained struvite can be promisable because the most of examined physical, physiological, morphological and biochemical characteristics of plants were at least at same level as those ones grown on substrates contained commercial fertilizers. Almost all examined parameters were more favourable comparing to control treatment.

ECONOMIC EVALUATION OF THE PRODUCTION OF STRUVITE-ENRICHED FERTILIZERS FROM LIVESTOCK WASTE

Introduction

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

One of the main documents comprising this Economic Assessment is the Cost-Benefit Analysis (CBA). To carry out the CBA, the parameters used and obtained in the experience of the pilot plant developed in Spain have been considered. The partner La Unió has overseen developing this pilot experience and of coordinating the drafting of this document, therefore, it has been much more efficient and precise its execution.

It has been considered that the important thing is to have a reference model that can be adapted by any other partner of the project to its country or by any other actor interested in starting a similar experience to the one developed. For reasons of time, budget and variety of data, four CBAs have not been carried out, but one that can be fully extrapolated to other European realities.

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 introducing the specific values of each territory automatically generates the profitability of the process.

This tool (Excel book) has also been incorporated, with its relevant explanations, in the financial analysis of this document and will be part, together with this document, of the project results

The other points previously developed in this Economic Evaluation document: market, marketing, eco-label, are common to the whole MED territory and are also developed specifically for each of the project partner countries. In this case, it has not been necessary to have empirical data, so it has been possible to work with time for each of the countries.

All these points initially consist of the common analysis that has been achieved through discussions, shared documents, and meetings between the entire Consortium. While the final part of these points consists of the reservations and differences raised by each of the territories participating in RE-LIVE WASTE, which logically, are given by the different existing 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.[15]

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 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

15

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.

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.

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.

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.)

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).

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.

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.

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.

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.

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)[16] considers prices between 300 and 800 USD/TN. Westerman et al (2010)[17] consider 330 USD/Tn. SERECO's experts (project partners) propose a valuation between 200 and 400

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[16] 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.

[17] 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.

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.

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.

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.

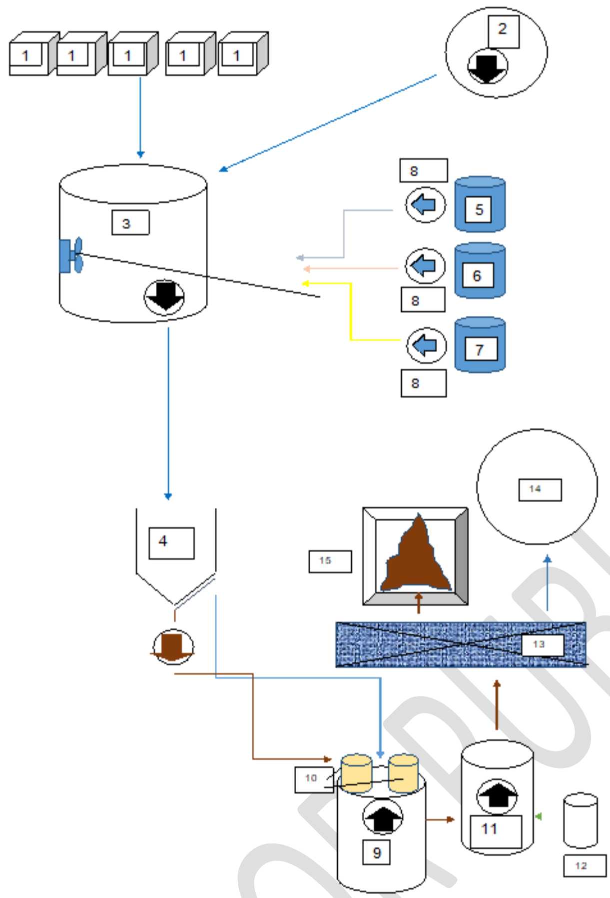
Can you add value and compete on issues other than price?

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.

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.

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

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.

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 register the new fertilizer and secondly, we must consider voluntary certifications that validate respect for the environment.

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

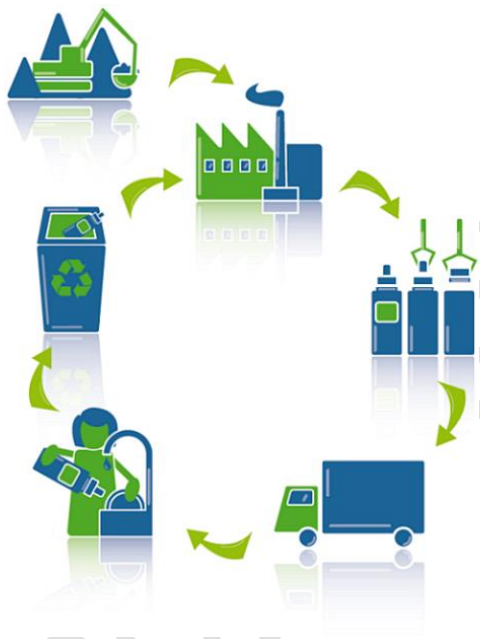
The application must be submitted to the competent body in one of the Member States of origin. If the product originates outside the European Community, the application may be submitted in any of the Member States in which the product is to be placed on the market.

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

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.

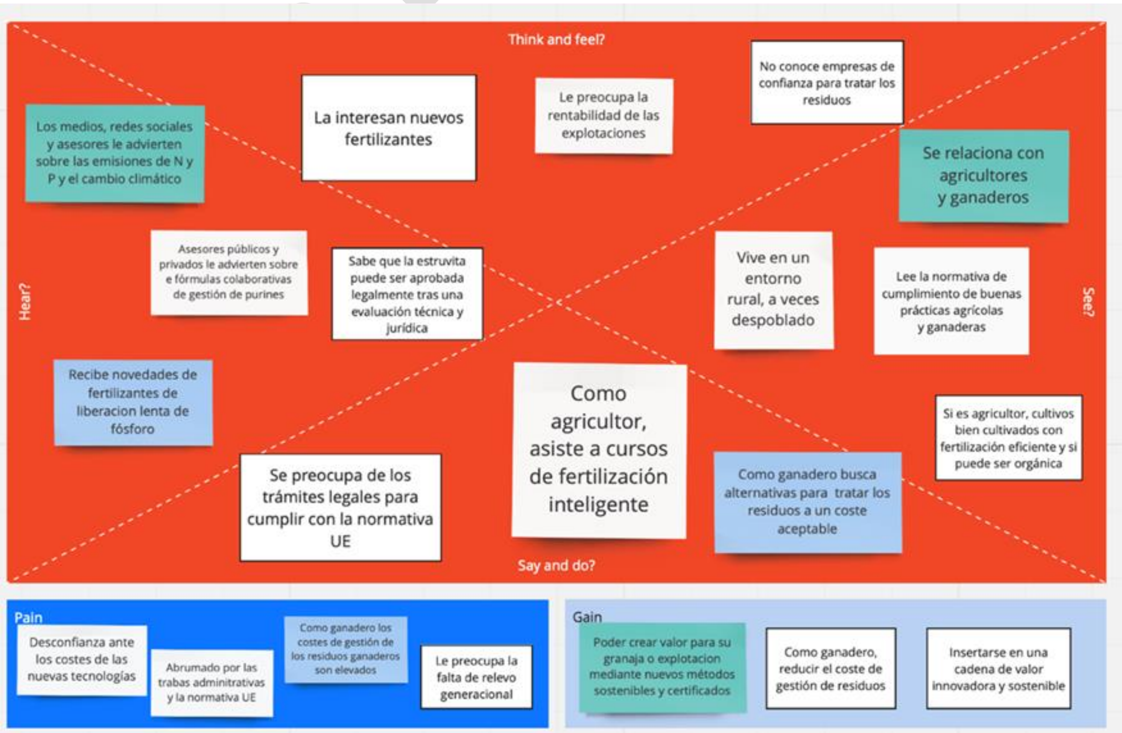
- ✓ Experimental data. They have been collected during the validation phase of the prototype, during the start-up and operation of the pilot plant.

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). It involves universities and research organizations (NRD-UNISS, CUT, FAFS UNSA), public authorities (IMIDA, Laore, DoE), 2 specialised companies (SERECO and FYNECO), a regional sectoral agency (SERDA), and 4 livestock SMEs (ALIA, Animalia Genetics, Cooperativa Produttori Arborea, PD Butmir), and 1 professional agricultural and livestock organization (La Unió).

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:

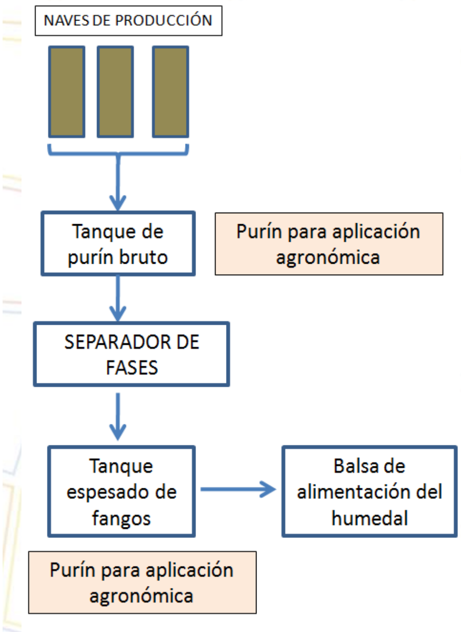
The first one of them is the logistic. The plant has to be located where the effluent supply is constant.

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.

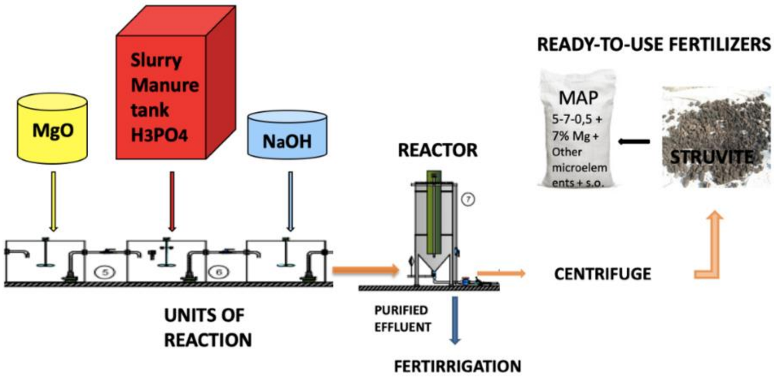
The project consisted in the execution of experimental tests to obtain O-SEP (Organic Struvite Enriched Precipitate) from various types of initial influences. Thus, a cycle of tests was carried out with the pig manure produced by the farms present in the experimental center, while another cycle of tests 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.

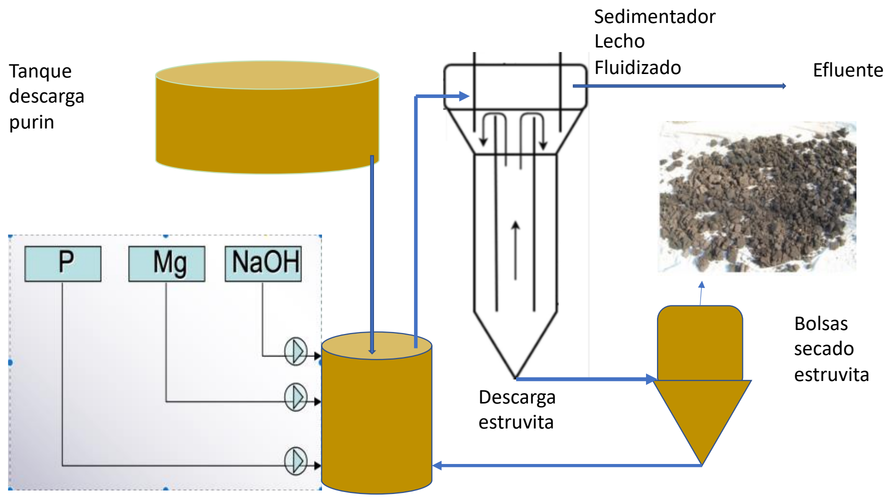
The specific process has so far not been tested under real conditions in Europe. Here the technology has an important role, and based on the accumulated experience, the project has contemplated to test, in the pilot experience, the Sermap® technology, a technology used is quite simple to be managed by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

Possible institutions/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.

Financial Analysis-Bosnia and Herzegovina

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
- ✓ Yield of fertilizer: 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)[18] contemplates prices between 300 and 800 USD/Tn. Westerman et al (2010)[19] 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 275 €/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	0.275	70,125
Liquid effluent (m^3)	10,500	0.1	1,050
		TOTAL	**71,175**

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.
- ✓

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

[18] 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.

[19] 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.

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:

- ✓ Construction license. Tax required to carry out any work. It is usually 3% of the investment budget although here we have taken into account 5% for possible contingencies;
- ✓ Construction 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 €;
- ✓ Finally, it has been considered that the whole investment cost will be financed and therefore will imply additional interest and commission costs. It has been calculated that this extra financial cost will be 10% of the total investment financed.

Facilities cost. YEAR 1			
Description	€/unit	nº units	Subtotal (€)
Structural works	10,305	1	10,305
Electrical installation	4,500	1	4,500
Pipes	1,477	1	1,477
Valves	4,259	1	4,259
Agitator	500	1	500
Submersible pump	2,500	1	2,500
Mohno pump	2,150	1	2,150
Dosing station	8,200	1	8,200
External connections	2,800	1	2,800
Tank A	5,000	1	5,000
Settler B	8,000	1	8,000
Tank C	5,600	1	5,600
Fliter Bags and frames	750	1	750
Sensors	8,500	1	8,500
Collection trolley	850	1	850
...			0
		TOTAL	**65,391**

Previous Facilities cost. YEAR 1			
Description	€/unit	nº units	Subtotal (€)
Tank for sub irrigation	4,000	1	4,000
Storage tank	18,000	1	22,000
Dry System	3,000	1	8,000
Existing rook and platform	3,000	1	4,000
Homogenization tank	3,800	1	3,800
			0
		TOTAL	**41,800**

Taxes and project	
Description	€
Building License	5,360
Building project	2,500
Plant Assembly	15,000
Cost loan	10,719
TOTAL	**33,579**

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.	71,205
Resid. rate value	30%
TOTAL	**21,362**

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	35,986
Resid. rate value	50%
TOTAL	**17,993**

The total investment for the construction of the plant is around 120 K €, including the taxes and subtracting the residual value. So, we are going to have a total investment around 136 K €.

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 €/litre
  - Magnesium oxide (50%). MgO. Average dose: 12 Kg/m^3. Price: 0.085 €/kg
  - Caustic Soda (30%). NaOH. Average dose: 0.5 kg/m^3. Price: 0.50 €/kg

Reagents. YEAR 1			
Name	kg	€/kg	Subtotal (euros)
Phosphoric acid 73%	*15.000*	*0,88*	13.200
Magnesium oxide 50%.	*180.000*	*0,085*	15.300
Sodium Hydroxide 30%	*7.500*	*0,5*	3.750
			0
		TOTAL	**32.250**

- ✓ Energy. Empirically it has been bought that the consumption of the process is 120 Kw/h, considering the current prices this means almost 4,000 € 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	3,942
Insurances	2,000
Renting	3,600
Maintenance	14,077
TOTAL	**23,619**

Total production costs amount to approximately 56 K.

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**
0						-155,393		
1	106,175	119,408	55,331	53,300	45,000	-78,864	-78,864	-234,257
2	106,175	0	55,869	53,300	45,000	42,006	-35,858	-192,251
3	106,175	0	55,869	53,300	45,000	42,006	5,148	-150,245
4	107,237	17,993	56,428	54,366	45,450	23,900	29,049	-126,345
5	108,309		56,992	55,453	45,905	41,768	70,817	-84,576
6	109,392		57,562	56,562	46,364	41,632	112,449	-42,945
7	110,486		58,137	57,694	46,827	41,482	153,931	-1,462
8	111,591	17,993	58,719	58,848	47,295	23,327	177,258	21,865
9	112,707		59,306	60,024	47,768	41,145	218,403	63,010
10	113,834		59,899	61,225	48,246	40,956	259,359	103,966

IRR	**7.0%**	**PAYBACK (years)**	**5.99**

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 7% is not particularly 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.

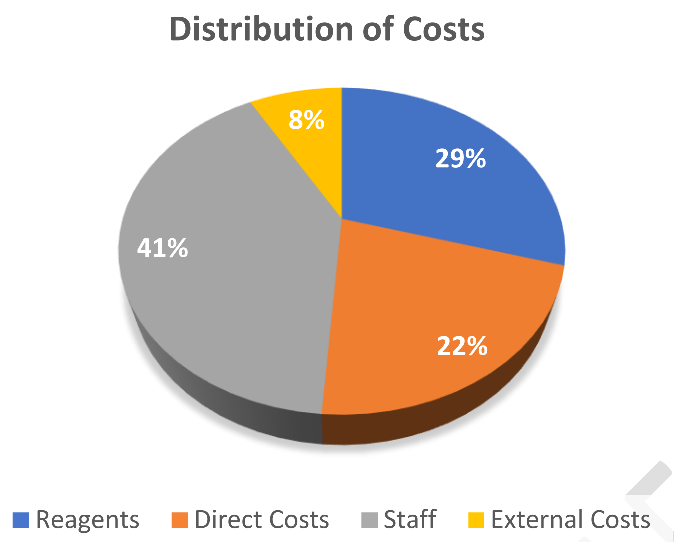
The recovery of the investment in just over 6 years, the not excessive initial investment required, the simplicity of the technology and the urgent need to achieve sustainable solutions for the management of livestock by-products make RE-LIVE WASTE a reference to be taken into account, both by public 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.

POLICY GUIDELINE

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	**WP-4**
Activity n and title	**4.5 – Transferring knowledge to public actors and policy makers**
Deliverable n. and title	**D451 – Policy guideline document**
Responsible Partner	**Department of Environment-MOA**
Participating partners	**CUT, Faculty of Agriculture and Food Sciences, LAORE (Sardegna), SERDA, Sereco Biotest snc di Luca Poletti, UNISS, ALIA, FGN, LAUNIO**
Main authors	**Georgia-Elina Zoi**
Reviewers	**All partners**

What is this document, to whom it is addressed to and what is its purpose

This document is the Policy Guideline Document of Re-Live Waste Project.

Its purpose is to inform policy makers about developments in the EU-branded fertilizers sector, organic fertilizers, the new Regulation that will take effect on July 16, 2022, and the preparations that need to be made so that the implementation of the Regulation is timely and successful in all Member States.

The innovative technology developed as part of the Re-Live Waste Project has led to the production of an organic fertilizer, struvite, which is expected to be added to the EU's component material catalog with the next amendment to the Fertilizer Regulation.

EU member states are called upon to form a favorable framework for the dissemination of this innovative technology and new product, support the continuation of research where needed, training and education of existing and new farmers, investment in technology implementation and production and dissemination of the product within the circular economy.

EU call on all public actors and policy makers to adopt policies, legislation and measures that will allow the production and introduction of struvite in the fertilizer market, while at the same time support farmers and communities in managing livestock waste in an eco-friendly, beneficiary, and profitable way.

CONTENTS

The first part presents the current legal framework, the expected changes, for which Member States will have to or should be prepared, and the strategies on which the changes promoted in the EU are based.

The second part provides a brief overview of struvite as a fertilizer, the technology developed under the ReLive Waste project, and the benefits of both applying this technology and using struvite.

In the third part, reference is made to the strategies and financial frameworks that the EU sets for financing the development and evolution of technology, education on this new, innovative technology, the dissemination of information about the technology and the benefits of struvite and especially the application of technology for the production and use of this fertilizer.

Section one the politicy and the legal framework

1. The problem

The development of intensive livestock farming across the European Union is leading to environmental problems such as water and air pollution and is contributing to climate change. The accumulation of large numbers of animals in confined and enclosed spaces, where animals are fed mainly on commercial fodder, leads to the creation of waste, liquids and cisterns, which in large concentrations are dumped on the ground in and around the farms. Storage spaces are seldom sufficient, so that waste, despite existing restrictions, is discarded when storage facilities are filled, even if the conditions are not met. This often leads to higher concentrations than allowed.

Livestock waste is characterized by high organic load, high concentrations of nutrients such as nitrogen, phosphorus, potassium, high electrical conductivity, and increased boron concentration.

It is estimated that agricultural activities, including livestock farming, account for 50% of total nitrogen disposal in surface water.[20] Impacts occur around farms but also far away from them, being a global problem.

Livestock and agricultural activities cause, among other things, ammonia (NH_4^+) emissions which contribute to the process of soil acidification, water eutrophication and pollution of the lower atmosphere with ozone together with other pollutants (sulfur dioxide, organic oxides of nitrogen, volatile organic compounds).

Furthermore, all activities related to livestock and fertilizer use cause the release of nitric oxide (N_2O) and methane (CH_4), a greenhouse gas with a global heating capacity 21 times higher than carbon dioxide (CO_2).

2. The suggested solution in the Re-Live Waste Project

The identity of the Project

The Re-Live Waste project "Improving innovation capacities of private and public actors for sustainable and profitable REcycling of LIVEstock WASTE" is implemented within the INTERREG Mediterranean program.
The total budget of the project (€ 2,285,087.50) is co-funded by 85% (€ 1,556,934.38) from the European Regional Development Fund and by 15% (€ 385,390.00) from national funds.
The program involves four European Mediterranean countries, Italy, Spain, Cyprus and Bosnia-Herzegovina.

The proposed solution

The main goal of the program is to implement an innovative technology for the recovery of nitrogen and phosphorus from livestock waste and their conversion into a high-value, environmentally friendly fertilizer based on struvite.

The new technical solutions implemented in the project aim to reduce the environmental impact of intensive livestock farming, reducing the volume of liquid livestock waste and the risk of contamination of the aquifer and groundwater by recycling nutrients that can be recycled.

The project also aims to improve the lives of the settlements around the livestock farms, reducing the unpleasant odors produced by them.

Four pilot plants in the four Mediterranean countries develop technology by testing different cost techniques and comparing their results to the quality of the product produced.

[20] **COM(2010) 47 final**

In the same countries, the produced product is tested in crops in order to determine its effectiveness.

The adoption of technology by farmers will allow them to comply with the directive on nitrates and pollute the environment less or not at all, while the production of a marketable product will make the investment in new technology sustainable, helping to develop new jobs.

3. The circular economy - the European solution framework

Until the end of the 20th century, the economic model that was followed was linear: extraction of raw materials from nature - production of products - consumption - disposal. This model on the one hand led to the systematic removal of resources from the earth, on the other hand created a large volume of waste.

In the 1970s, some circles began a discussion for adopting a circular model. It took decades for the debate to move to official states and the EU.

In the circular model, the last stage of the process (disposal) is connected to the first (extraction of raw materials), closing the circle and maintaining the resources within the economy. Instead of extracting raw materials from the earth, reducing its reserves, the same resources are recovered from the waste at the end of the life of the products and returned at the beginning of the process.

In a world where demand and competition for finite and sometimes scarce resources will continue to increase, and pressure on resources is causing greater environmental degradation and fragility, Europe can benefit economically and environmentally from making better use of those resources[21].

A prerequisite for the efficient use of waste is the design of products from the beginning in a way that makes it possible to recover useful materials at the end of their life. The reduction of waste as well as the utilization of all the resources that can be recovered from them, are elements that must be taken into account by both producers and consumers throughout the process.

Acknowledging that the process will always maintain a linear element, as there will always be a need for an inflow of raw resources from the earth while there will always be a percentage of waste that cannot be used, the EU has set a goal to gradually reduce the primary materials as well as the residual waste. Since 2015 EU called on member states to submit National Strategic Plans for the circular economy.

<u>Fertilizers - one of the first areas of waste recovery</u>

In 2015, the European Commission proposed an action plan to promote the circular economy in the European Union[22]. One of the first areas to be targeted was the fertilizer sector.

The EU's fertilizer policy, which was reflected in Regulation 2003/2003[23], concerned exclusively mineral or chemical fertilizers.

[21] **COM (2014) 398 final**
[22] COM (2015) 614 final
[23] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:32003R2003

While European legislation did not preclude the use of manure, which under certain conditions could be classified as a "by-product" of marketable value, organic fertilizers that could be used in agriculture were not recognized as fertilizers.

The new Fertilizer Regulation (2019/1009)[24], issued under the 2015 Action Plan, provides an opportunity to add to the list of EU fertilizer products both derived products and recovered waste as part of the effort to preserve all substances that may be recovered, in parallel with the waste management effort.

4. From the Nitrates Directive to the new Fertilizer Regulation

From bans and restrictions on the circular economy

Environmental protection has always been an EU goal. However, the first policies concerned restrictions and prohibitions. In the field of livestock waste, the main prohibitions were provided in the Nitrates Directive (Directive 91/676 / EEC[25]).

The implementation of the Directive ensured the monitoring and reduction of the presence of nitrates in the water, but over the years and the increase in livestock, it is clear that the restriction is not enough to solve the problem.

The adoption of the EU model of the circular economy makes the breakthrough that this sector requires for a comprehensive solution to the problem. The goal is not only to manage livestock waste by stopping the disposal of nitrates but also to produce high-value products that can be used in agriculture.

The EU is synonymous in the consumers' minds with high quality products. The specifications set by the EU and the controls it implements ensure the quality of European products.

In order for a product to receive the CE mark, it must meet the high specifications required by the EU. In fertilizers, it is not enough for a product not to be harmful; it must be beneficial, its usefulness and value must be proven, and its production processes must be tested, verified and found environmentally sound. The production of an organic fertilizer that will bear the EU mark, even if it comes from recovered waste, must meet the same high requirements as the mineral products that have already been approved by the EU.

The Nitrates Directive

One of the first EU policies aimed at protecting the environment, which is still in force today, is the Council Directive of 12 December 1991 on the protection of water from nitrate pollution of agricultural origin (91/676 / EEC). The Nitrates Directive, as is well known, is included in the EU's general policy on water, as described in Directive 2000/60 / EC[26] of the European Parliament and the Council of 23 October 2000, establishing a

[24] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R1009
[25] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:31991L0676
[26] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32000L0060 [8] Annex III of Directive

framework for EU action in the water policies, known as the Water Framework Directive. Directive 91/676 / EEC has done its utmost to limit the spread of nitrate ions in the soil.

Starting with the recording of vulnerable zones, which represent areas that are either polluted or may be polluted with nitrate ions, Member States are adopting Good Agricultural Practice Codes (which, however, according to the Directive, are optional for them), while at the same time and mainly drawing up Action Plans either common to all the vulnerable areas of their territory or different, depending on the region and its specific conditions.

Among the measures to be included in the Action Plans are the following rules:

1. the periods during which the spread of certain types of fertilizers on the soil will be prohibited
2. the capacity of the manure storage containers (so that no manure is scattered on the ground during periods of prohibition)
3. limiting the amount of fertilizer allowed to be propagated in the soil in the context of good agricultural practice.

The measures of each Action Plan should ensure that for each agricultural or livestock unit, the amount of manure added to the soil each year, either by humans or by animals, does not exceed 170kg per hectare.[8]

The Commission may, by a decision of a limited duration, grant a derogation to a Member State for a particular area, provided that the Member State proves that the dispersal of a larger amount of manure will not result in the accumulation of larger amounts of nitrate ions in the soil.

Member States must monitor both the quality of water and the implementation of the Directive and the compliance of farmers and inform the Commission. So far, according to the Commission's reports, all Member States have complied and submitted Action Plans.[27]

However, compliance with the Directive is a challenge for farmers, especially given the intensification and increase in livestock.

<u>The new Regulation 2019/1009 on fertilizers</u>

The EU's fertilizer policy so far has been exclusively on mineral or chemically produced fertilizers. On June 5th, 2019, the European Parliament and the Council adopted Regulation (EU) 2019/1009 establishing rules on the availability of EU fertilizing products on the market and amending Regulations (EC) 1069/2009 and (EC) 1107/2009 and the repeal of Regulation (EC) 2003/2003.[28]

The principles and objectives of the circular economy are reflected in the Regulation, stating that “there is a need to make use of recycled or organic materials for fertilising purposes. Harmonised conditions for making fertilisers made from such recycled or organic materials available on the entire internal market should be established in order to provide an important incentive for their further use. Promoting increased use of

[27] COM(2010) 47 final, COM(2018) 257 final
[28] The repealed Regulation (EC) 2003/2003 is the current Regulation on Fertilizers, while Regulations 1069/2009 and 1107/2009 concern animal by-products and plant protection products respectively [11] Article 42, par. 2

recycled nutrients would further aid the development of the circular economy and allow a more resource-efficient general use of nutrients, while reducing Union dependency on nutrients from third countries. The scope of the harmonisation should therefore be extended in order to include recycled and organic materials."

The Regulation for the first time refers to materials such as struvite, biochar and ash-based products and states that there is a market demand for the use of such "recovered waste" as fertilining products. In order to produce products that bear the CE mark and meet the high standards of the EU, "certain requirements are necessary for the waste used as input in the recovery operation and for the treatment processes and techniques, as well as for fertilising products resulting from the recovery operation, in order to ensure that the use of those fertilising products does not lead to overall adverse environmental or human health impacts. For EU fertilising products, those requirements should be laid down in this Regulation."

Therefore, as of the moment of compliance with all the requirements of this Regulation, such products should cease to be regarded as waste within the meaning of Directive 2008/98/EC, and it should, therefore, be possible for fertilising products containing or consisting of such recovered waste materials to access the internal market. To ensure legal certainty, take advantage of technical developments, and further stimulate the incentive among producers to make more use of valuable waste streams, the scientific analyses and the setting of recovery requirements at Union level for such products should start immediately after the entry into force of this Regulation."

The Regulation passed in June 2019 and will come into force on 16 July 2022, giving Member States three years to prepare.

According to the Regulation[11], without undue delay after 15 July 2019, the Commission shall assess struvite, biochar and ash-based products and if such assessment concludes that the criteria in point (b) of paragraph 1[29] are fulfilled, the Commission shall adopt delegated acts for its amendment and inclusion of these materials in the list of Component Materials included in Annex II to the Regulation. If a material is included in this list, it may be a component of a fertilizing product bearing the EU mark.

The Parliament and the Council have authorized the Commission to issue amendments to the Regulation[30] to include the above products in the EU's fertilizer components, without the need to follow the time-consuming process of amending the Regulation by the Parliament and the Parliament. Council.

The Commission's scientific committee is already working on the existing information and, given that there is enough evidence that there is the technology to produce these products and their effectiveness, it will immediately label struvite as a component of EU fertilizers. This will pave the way for its utilization, but also for the development of the relevant technology.

As mentioned above, the Re-Live Waste program develops the technology in four small pilot plants, enhancing the struvite support file, while conducting agronomic analyses and financial reports that provide tools to further strengthen the effort to take advantage of this recovered waste.

29 See Annex II
30 Article 42, par. 1

When it comes to the above-mentioned regulation, the scientific members of the European Committee examined the possibility of struvite to be included in the list of bio- fertilizers. During the meeting that took place in November 2020, the committee decided on the requirements that struvite needs to meet in terms of composition, the allowable ways that this material can be recovered form waste so that it meets the quality criteria set. The aforementioned document is now available online (item 4.2.a. ANNEX precipitated phosphate salts (1)), and it is expected to become in effect starting March 2021.

According to the updated provisions of the Regulation, new criteria need to be met on the quality characteristics of the struvite produced as report in the above-mentioned ANNEX. Specifically, in paragraph 3 of the ANNEX it is stated that:

"*3. The precipitated phosphate salts shall contain:*

(a) *a minimum phosphorus pentoxide (P_2O_5) content of 16 % of the dry matter content;*
(b) *a maximum organic carbon (Corg) content of 3 % of the dry matter content;*
(c) *no more than 3 g/kg dry matter of macroscopic impurities above 2 mm in any of the following forms: organic matter, glass, stones, metal and plastics;*
(d) *no more than 5 g/kg dry matter of the sum of the macroscopic impurities referred to in sub-point (c)*."

Based on the above, it becomes apparent the need to further investigate the sustainable and economical production of marketable struvite from livestock waste through novel methodologies that meets all the requirements of the new regulation, that would ultimately become widely accepted and applied.

5. Obligations of Member States in accordance with the new Fertilizer Regulation

The availability in the market of high value products that meet EU standards presupposes the control of these products.

The control is carried out by bodies evaluating the compliance of the products with the European legislation. The Regulation[31] describes the requirements that these bodies must meet.

These bodies are in turn controlled by the Member States. The competent body is either the national accreditation body of Regulation 765/2008 or an authority designated by the Member States to perform these responsibilities.

This authority, called the "notifying" authority, is responsible for setting up and carrying out the necessary procedures for the assessment and notification of conformity assessment bodies, notifying them to the Commission and other Member States, in accordance with the procedure and using the electronic means that have been created and being managed by the Commission, as well as the monitoring of notified bodies.

The notifying authority shall inform the Commission of their procedures for the assessment and notification of conformity assessment bodies and the monitoring of notified bodies, and of any changes thereto.

The notification of the bodies is made by the notifying authority at the request of the body. In the event that during the monitoring period the notifying authority finds, after an investigation, that the body no longer

[31] Article 24

meets the requirements of the Regulation or fails to fulfill its obligations, the notifying authority has the right to restrict, suspend or withdraw the notification and inform the Commission and other Member States.

At the same time, it ensures that the files of this bodies are either processed by another notified body or kept available for the responsible notifying and market surveillance authorities at their request.[32]

In addition to evaluating products by notified bodies, market surveillance authorities in each Member State may evaluate a product if they have sufficient reason to believe that it poses a risk to human, animal or plant health, safety or the environment. If during the evaluation it is found that the product does not comply with the requirements of the Regulation, they inform the relevant economic operator by requesting that the appropriate measures be taken, while at the same time informing the notifying authority.

In the event that the product is available in more Member States, the Member State of which the authorities found non-compliance shall inform the Commission and other Member States. The measures that can be taken are gradual and can lead to the complete withdrawal of the product from the EU market.

The Regulation also provides for the obligations of manufacturers, their authorized representatives, importers and distributors, which must be controlled by the market surveillance authorities.

Section two technical presentation

The Re-Live Waste project provides for the operation of four pilot plants in four Mediterranean countries. So far, the four plant are operational, there are results of agronomic test performed in Cyprus and Spain, while for Italy and Bosnia and Herzegovina are still ongoing.

The Plant in Bosnia and Herzegovina

The pilot plant is located in Bosna and Herzegovina, area of Sarajevo, at PD Butmir farm. The area occupied by the plant is 600 sq.m. and it processes 6000 L of raw slurry from cattle per day, producing about 40 kg of struvite enriched precipitate. The equipment cost was € 122.703,13 which was acquired from the Interreg MED RE-LIVE WASTE project. The Pilot plant was operated by representatives of the project partners and staff which was hired as a local technical team. The most valuable support was from the chemist about chemical process that occur in production of struvite. Support was provided also by the staff from PD Butmir.

[32] **Article 30**

During the operation and testing of the pilot plant the staff was trained on the treatment of the manure on farms and in pilot plant as established within the project.

The characteristics of O-SEP (Organic Struvite-Enriched Precipitate) produced in Bosnia and Herzegovina.
The initial waste used for the production of struvite at the PD Butmir plant consisted of a 100% raw cattle slurry. The final fertilizing product consisted of really small struvite crystals and contained 34g Nitrogen (N), 9.2 g Potassium (K), 58.6 g Phosphorus (P) and 47.4 g Magnesium (Mg) per kg.

The agronomic protocol.

A common protocol of analysis was set up to establish the testing steps of the struvite produced in each plant. The selected crops were baby leaf lettuce (*Lactuca sativa L.*) and radish (*Raphanus sativus L.*) There was no limitation on the number of species that each research group could assess, obviously adapting the agronomic protocol for the new species that would be considered.

Agronomic analysis method and outcomes from the study in Cyprus.

Struvite is a slow-release fertilizer and has been tested compared to a commercial fertilizer. The tests were performed with lettuce seeds (*Lactuca sativa*) and radish (*Raphanus sativus*) on peat substrate, peat substrate enriched with struvite or commercial fertilizer at low dose and peat substrate enriched with struvite or commercial fertilizer at normal dose (double the low dose). Also, the germination of lettuce (*Lactuca sativa*), radish (*Raphanus sativus*) and garden cress (*Lepidium sativum*) seeds in growing media extracts from the above substrates was also tested. Moreover, the growth of seedlings was monitored for 30 days. Finally, after the harvest, growth and physiology parameters of the plants, their content of nutrients and other elements, their post-harvest behavior, and the composition of the substrates on which the crops were grown were studied.

Struvite from the Cypriot pilot was proven to be a fertilizer that competes well with commercial fertilizers, contributing to the improvement of the physicochemical properties of the substrate (e.g., water capacity). The growth of the plants was similar, with the struvite competing with the commercial fertilizer, and in other parameters one being superior while in others the other, depending on the type of crop and the amount of fertilizer used. In general, the use of fertilizers had better results than growing only on peat substrate. Normaldose struvite, however, appeared to increase plant nutrient content (nitrogen, potassium, and phosphorus) at levels similar to commercial fertilizer at normal doses, while radishes, in addition to the above, increased magnesium and calcium.

Plants grown with struvite had a similar post-harvest behavior to those grown with commercial fertilizer. The germination of garden cress seeds was significantly higher with the normal dose of struvite compared to all other extracts, while the germination of lettuce and radish seeds was not affected by struvite. In the substrate the organic matter and organic carbon were higher where struvite was used, while they had higher pH. Commercial fertilizer enriches the plants growing substrate with more nitrogen while struvite with more phosphorus, sodium and magnesium.

Benefits of struvite production and use

The production and use of struvite as a fertilizer has multiple benefits. It solves the problem of livestock waste management while the anaerobic process followed by the technology developed significantly reduces the emissions by the livestock farms, enabling everyone to contribute to the zero-emissions target set by the European Union.

The technology developed also provided a fertilizer derived from livestock waste, but free of pathogens (if the proper treatment of the waste is followed before the crystallization of the struvite). The analyses of the struvite produced following the methodology of the Cypriot plant proved that the Cypriot struvite is safe for use, while all pathogens were eliminated.

These, however, would not be enough if the struvite as a fertilizer was not effective. Analyses and comparisons with commercial fertilizers have shown that struvite produced by the Cypriot plant is just as effective as commercial fertilizers.

The promotion of its production technology through the treatment of livestock waste and its use as a fertilizer will help to achieve multiple goals: livestock waste management (compliance with the Waste Directive 2008/98/EC), reduction of greenhouse gas emissions from intensive livestock farming (achievement of the EU Climate Neutrality target by 2050), protection of soil and water (compliance with the Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources 91/676/EEC), return nutrients to the production chain and reduce the need to extract elements such as phosphorus from nature (Circular Economy Strategy), and produce food for all ("From farm to fork Strategy").

Table I: Comparison of the struvite produced in the pilot plants vs Requirements for PFC 1 (B)(I) of the Regulation EU 1009/2019

Parameters	Unit of measurement	Cyprus (CUT)- Struvite (agronomic evaluation)	Spain	Italy (UNISS)	BosniaHerzegovina	Requirements for CMC 12	Requirements for PFC 1(B)(I): Solid OrganoMineral Fertiliser (page 42 of the Regulation)
Total Phosphorus pentoxide (P_2O_5)	% w/w D.M.	24.24	10,39	7,71	13,40	-	At least 2% w/w D.M. (Total phosphorus pentoxide)
Phosphorus pentoxide (P_2O_5) (from phosphate-($P\text{-}PO_4^{3-}$))	% w/w D.M.	10.21	4,36	3,08	13,40	16	-
Total Nitrogen (TN)	% w/w D.M.	4.96	1,69	2,93	3.40	-	At least 2 % w/w D.M.
Total potassium oxide (K_2O).	% w/w D.M.	0.66	0,44	2,79	1.11	-	
Sum of K_2O, Total P_2O_5, Total Nitrogen	% w/w D.M.	29.87	12,52	13,43	17.91	-	At least 8 % w/w D.M.
Water Content (105 °C)	% w/w	12	-	-	-	-	-
Water Content (40 °C)	% w/w	35	14,9	10,7	9		
Organic carbon (C org)	% w/w D.M.	27.4	3,8	27,9	22,3	Maximum 3	At least 7.5 % w/w
Solid form		Solid	Solid	Solid	Solid	-	Solid
Macroscopic impurities above 2 mm (organic matter, glass, stones, metal and plastics)		Not visible	Not present	Not present	Not visible	No more than 3 g/kg D.M.	
Sum of the macroscopic impurities (organic matter, glass, stones, metal and plastics)	% w/w D.M.	Organic matter 48.8 Not visible impurities.	Not present	Organic matter 48.1 Not visible impurities	Organic matter 21.55 Not visible impurities	No more than 5 g/kg D.M.	
Struvite percentage (XRD analysis)	%	89.2 (highest obtained at the pilot: 99.6)	50.0	63.0 (the highest obtained 86)	91.0		

D.M.: Dry matter content at 40 °C Total P_2O_5= TP/0.436 P_2O_5 (from phosphate) = $P\text{-}PO_4^{3}$/0.436

Concluding remarks

To summarize, the project was successful in constructing three new pilot plants and upgrading an existing one for struvite precipitation. Each plant processed different treated and untreated livestock waste while struvite precipitation followed distinct steps in each pilot that resulted in medium and high quality of struvite and struvite enriched precipitated. In most of the cases, pathogens and carcinogens were not detected in the final product, allowing for its use for both gardening and crops. The agronomic evaluation proved that both struvite and the struvite enriched precipitate produced in the pilots have the potential to substitute commercially available fertilizers. Finally, N and P abandonment through struvite crystallization was substantial in all processed effluents, significantly alleviating their environmental footprint.

Section three struvite production and dissemination possibilities

The EU new policy for the next seven years is characterized by two important documents: the European Green Deal[33] and the Commission's 2020 Action Plan for the Circular Economy[34].

These documents focus on the key issues that will drive the EU's policy and economy from now on. Human's relationship with the earth, with the natural environment, the way we manage the natural resources of the planet and the ecosystems, our impact on the planet, the climate, the other species and equality between all people are the backbone of new EU policies.

No matter how much ideological differences and concerns persist, no matter how much one criticizes some of EU policies, the reality is that the Old Continent perceives more quickly and more consciously the challenges facing the world, the Earth, humanity. EU resolutely pioneers decisions and policies that other major powers on the planet do not dare.

The EU is not content with words and legislation. Policies requires money to happen. Now, more than ever, Europe realizes that funds must be distributed fairly, purposefully and support EU and citizens worldwide. Climate change and its effects cannot be dealt with by a single state, not even by Europe alone. They depend on the conscious participation of all states, all peoples.

Europe is a pioneer. It enables its own citizens, businesses, employees, consumers, to become pioneers in this global effort.

Funding tools

Realizing that change requires money has led to a Sustainable Europe Investment Plan[35]. Almost all EU financial tools are in the service of promoting sustainable development policies, the circular economy, a climate-neutral Europe. The investment plan focuses on tackling climate change. However, almost all EU financial tools include actions on the circular economy, environmental protection and sustainable development.

"Next generation EU"[36]

Next Generation EU is a €750 billion temporary recovery instrument to help repair the immediate economic and social damage brought about by the coronavirus pandemic. The 750 billion euros are divided as follows:

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33 **COM (2019) 640 final**
34 **COM (2020) 98 final**
35 **COM (2020) 21 final**
36 **https://ec.europa.eu/info/strategy/eu-budget/long-term-eu-budget/2021-2027_en; https://ec.europa.eu/info/strategy/recovery-planeurope_en#nextgenerationeu**

390 billion will be distributed through subsidies and 360 through loans[37]. The "Next generation EU" initiative is based on three pillars:

1. Supporting Member States to recover, repair and emerge stronger from the crisis;
2. Kick-starting the economy and helping private investment to get moving again Learning from the crisis;
3. Learning the lessons of the crisis and addressing Europe's strategic challenges.

"All national recovery and resilience plans will need to focus strongly on both reforms and investments supporting the green transition. To follow the commitment of the European Council to achieve a climate mainstreaming target of 30% for both the multiannual financial framework and Next Generation EU, each recovery and resilience plan will have to include a minimum of 37% of expenditure related to climate. Europe heads towards climate neutrality by 2050, and is set to significantly increase its greenhouse gas emissions reduction ambition for 2030. In order to, reach the climate ambition to decrease emissions by 55% in 2030 below 1990 levels, Member States should present reforms and investments to support the green transition in the fields of energy, transport, decarbonising industry, ***circular economy****, water management and biodiversity. This is also consistent with the key areas of investment identified in the context of the European Semester. In doing so, Member States should build on their National Energy and Climate Plans in which they define their national contributions to the collective EU-wide climate and energy objectives, and outline reforms and investments they intend to implement over the period 2021-2030 to deliver them".* (Annual Sustainable Growth Strategy 2021[38]).

The next generation EU funds represent a great opportunity to the member states participating in the project, as they have money to invest in green transition and in particular in circular economy, it will be worth to invest it in developing further research to upgrade the plants to obtain a struvite compliant with the new regulation.

Coordination and guidance

The European Institute of Innovation and Technology will coordinate innovation initiatives for the circular economy in collaboration with universities, research organizations, industry and SMEs within the knowledge and innovation communities.

The development of digital technologies and their dissemination is one of the EU's goals related to the circular economy. The access of citizens, companies and institutions to disruptive and groundbreaking innovation will be made possible by the new strategy proposed by the Commission on Intellectual Property Rights, in order to, ensure that intellectual property continues to be a key factor in favor of the circular economy and the emergence of new business models.

[37] **https://www.consilium.europa.eu/en/infographics/recovery-plan-mff-2021-2027/**
[38] **https://eur-lex.europa.eu/legal-content/en/TXT/?qid=1600708827568&uri=CELEX:52020DC0575**

The European Innovation Council (EIC) supports entrepreneurs with innovative ideas, small businesses, and scientists, guiding them in funding opportunities, providing advice and networking opportunities to promote innovative ideas and develop them on a larger, global scale.

Research and Development Funding

The circular economy and environmental protection are based on the development of technology. The new Horizon Europe program, which will replace Horizon 2020 for 2021-2027 and will launch on January 1, 2021, will support the development of innovation, including waste recycling and raw material recovery.

Marie Sklodowska Curie's actions will be able to support the development of skills, training, and mobility of researchers in the sectors of the circular economy.

The Life program will continue to be an EU financial tool for environmental research. The circular economy and tackling climate change will set the stage for actions that will be supported by the new Life to improve water and air. Life's traditional nature and biodiversity sector will be linked to other policies, funding rural development programs, ensuring a more coherent approach. A simpler and more flexible approach will help develop innovative ways of dealing with environmental and climate challenges.

The European Regional Development Fund for the period 2021-2027 will continue to support two policy objectives: supporting innovation, digital economy and SMEs through smart and the media through Smart Specialisation Strategy (policy objective 1) and a greener, circular economy of low carbon emissions (policy objective 2).

The European Social Fund + will support upgrading skills and retraining about 5 million people for green jobs and the green economy.

Europe is targeting small and medium-sized enterprises and the workforce on the grounds that no one is left behind. The transition to a more circular, green, clean economy will have an impact on workers working in areas that will decline. Training and developing new skills will allow everyone to participate in the transition, mitigating the social consequences and motivating everyone to participate in the effort and change.

Private investments

The InvestEU program provides guarantees to cover the risk of financial and investment transactions in order to support the objectives of the European Green Deal on a Circular Economy and Climate Neutral Europe by 2050. InvestEU will support sustainable investment in all sectors of the economy. It will also disseminate sustainable practices between private and public investors, operating in an advisory capacity. In addition, it will implement a method for "sustainability control" based on which it will be required of project implementers that exceed a certain size to assess the environmental, climatic and social implications of these projects.

The European Investment Bank is becoming the EU's climate bank. Gradually, its share of funding for climate action and environmental sustainability will increase to 50% by 2025. It will use its own resources and EU budgetary support under various programs and facilities to finance climate action and environmental investments both inside and outside the EU. A significant part of this funding will be available under the program. InvestEU.

Other international and national financial institutions will play an increasing role in financing sustainability in line with EU policy objectives. The Commission will therefore work closely with them to explore how their activities could be aligned more closely with the European Green Deal objectives.

Participation of Member States

The EU sets the strategies, gives the general directions. It is up to the Member States to implement them, adopting new legislation or amending their legislation so as to either incorporate into their law a legislation that has already been passed, or to prepare for Directives and Regulations that will be approved within the framework of decided strategies, through financial tools but also through incentives for the implementation of these strategies.

State aid, subsidies, taxation

The rules for state aid will be revised by 2021. Member States will have greater opportunity to support measures needed to move from a linear to a circular economy, such as waste recycling and raw material recovery. Member States will be called upon to use fiscal tools to redirect public investment, consumption and taxation to green priorities, away from harmful subsidies.

The committee will work with Member States to investigate and record green fiscal practices. Tax reforms will be discussed to motivate producers, users and consumers to adopt sustainable behaviors. VAT rates should reflect the growing environmental requirements, supporting e.g. organic products.

Common Agricultural Policy (CAP)

Subsidies managed by Member States under the Common Agricultural Policy (CAP) should serve the nine objectives set, including action on climate change, environmental care, preservation of landscapes and biodiversity, food and health quality protection, vibrant rural areas.

The subsidy for farmers' income will remain the main pillar of the CAP. There will be more support for smaller farms and young farmers will be supported. Prerequisites for providing subsidies now will be the preservation of carbon-rich soils, obligatory nutrient management in order to, improve water quality by reducing ammonia and nitrogen oxides.

Farmers will be able to be rewarded for going beyond the mandatory requirements. Member States should develop plans to support and motivate farmers to follow practices that benefit the climate and the environment.

The new CAP aims to give a further impetus to the development of rural areas, including the position of stricter conditions for food quality and safety, and to provide financial incentives to support only those who comply with the rules, e.g. to reduce the use of pesticides and antibiotics.

The new policies will only be able to be implemented if farmers acquire knowledge and access to innovative technologies and practices. The development of national strategies for more powerful Agricultural Knowledge and Innovation Systems (AKIS) and their wider dissemination will be promoted.

Epilogue

All EU actors will work together on a common goal: a sustainable, climate-neutral Europe. The agricultural sector has a catalytic role to play in this effort. The development of disruptive technologies, their adoption and implementation require funding from all sectors: EU funds, private sector, and Member States. Europe dares to lead a safer and fairer world for a future that for some time seemed bleak, and now, with bold decisions, indepth changes and new policies, it seems optimistic and dynamic.

Europe is taking the reins, funding, and supporting technologies that provide solutions to the world's most serious problems, giving hope for the future of next generations. EU calls on all of us to participate, to mobilize our own forces and gives us the tools to do so.

In a unique and difficult time for our generation, EU decisions give hope. We can do it by working together, supporting each other with boldness, determination, and optimism.

ANNEX I

Useful definitions

The Fertilizer Regulation describes the struvite as "recovered waste". It is advisable, for clarification purposes, to cite some definitions.

Waste
"Any substance or object which the holder discards or intends to discard."[39]

The 2008/98/EC Directive on Waste followed Directive 75/442 of the Council of European Communities, which in Annex I contained a list of substances and objects considered waste in the then European Communities. This list has been revised and is now included in a separate text.[40] Furthermore, the Directive 2008/98/EC was amended by the Directive 2018/851/EC of May 30th, 2018.

The definition includes on the one hand an objective criterion (the inclusion of the substance or object in the Waste List) and on the other hand a subjective criterion of the intention of its holder. This criterion has been repeatedly clarified by the European Court of Justice[41], which notes that whether a waste will be classified as such depends on whether the holder "intends to exploit or trade it" - possibly for the needs of entrepreneurs other than the one who produced it - under favorable conditions for himself, in the context of a subsequent process, provided that this reuse is certain, does not require prior processing and is included in the following for the production or reuse process". Such waste, which is intended to be reused without treatment, is classified as a by-product.

By-product
«1. Member States shall take appropriate measures to ensure that a substance or object resulting from a production process the primary aim of which is not the production of that substance or object is considered not to be waste, but to be a by-product if the following conditions are met:

(a) further use of the substance or object is certain;
(b) the substance or object can be used directly without any further processing other than normal industrial practice;
(c) the substance or object is produced as an integral part of a production process and

[39] Article 3, point 1) Directive 2009/98 EC
[40] Commission Decision of 18 December 2014 (204/955 / EU)
[41] See indicative decision of the Fourth Department of the Court of Justice of the European Union (WEU) with number C-113/12 Donal Brady by Environmental Protection Agency

(d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental, and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts."[42]

Recovered waste

"Recovery" means any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy.[43]

“Material recovery” means any recovery operation, other than energy recovery and the reprocessing into materials that are to be used as fuels or other means to generate energy. It includes, inter alia, preparing for re-use, recycling and backfilling;[44]

“Treatment’ means recovery or disposal operations, including preparation prior to recovery or disposal Processing"[45]

“Backfilling” means any recovery operation where suitable non-hazardous waste is used for purposes of reclamation in excavated areas or for engineering purposes in landscaping. Waste used for backfilling must substitute non-waste materials, be suitable for the aforementioned purposes, and be limited to the amount strictly necessary to achieve those purposes[46]

While Directive 2008/98 on waste provides general definitions of waste, recovery and management, Article 2 (2) excludes from its scope, among other things, “animal by-products including processed products covered by Regulation (EC) No 1774/2002 (which has already been replaced by Regulation 1069/2009 on animal byproducts), except those which are destined for incineration, landfilling or use in a biogas or composting plant.

Therefore, while the definition of waste is in Directive 2008/98, the management of animal by-products is regulated by Regulation (EC) 1069/2009.[47]

The definitions of Regulation 1069/2009

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[42] Article 5 of the 2008/98 Waste Directive, as amended by the 2018/851/EC Directive

[43] Article 3 point 15) of Directive 2008/98

[44] Article 3 point 15a) that was added to the Directive 2008/98 by the Directive 2018/851

[45] Article 3 point 14) of Directive 2008/98

[46] Article 3 point 17a) that was added to the Directive 2008/98 by the Directive 2018/851

[47] Regulation (EU) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 on health rules for animal byproducts and derivatives intended for human consumption and on the repeal of Regulation (EC) No 1774/2002 (Animal Regulations) by-products).

It is useful again, before we move on, to look at some of the definitions used by Regulation 1069/2009 and which will be useful to us in understanding the regulations that follow and are currently binding on EU Member States.[48]

"Animal by-products": entire bodies or parts of animals, products of animal origin or other products obtained from animals, which are not intended for human consumption, including oocytes, embryos, and semen[49]

"Derived products": products obtained from one or more treatments, transformations or steps of processing of animal by-products[50]

"Manure": any excrement and/or urine of farmed animals other than farmed fish, with or without litter[51]

"Organic fertilizer" and "soil improver": materials of animal origin used to maintain or improve plant nutrition and the physical and chemical properties and biological activities of soils, either separately or together; they may include manure, non-mineralised guano, digestive tract content, compost and digestion residues[52]

"Pressure sterilization": the processing of animal by-products, after reduction in particle size to not more than 50 mm, to a core temperature of more than 133 °C for at least 20 minutes without interruption at an absolute pressure of at least 3 bar[53]

Livestock and manure do not fall under the definition of "products of animal origin ", which is listed for the purpose of avoiding confusion.[54]

Products of animal origin

- food of animal origin, including honey and blood;
  – live bivalve molluscs, live echinoderms, live tunicates and live marine gastropods intended for human consumption; and
  – other animals destined to be prepared with a view to being supplied live to the final consumer.

Animal by-products

Regulation 1069/2009[55] on animal by-products describes three categories of products, the management of which is regulated by the Regulation.

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[48] With the amendment of Regulation 2019/1009 on fertilizers, the Commission is authorized to amend Regulation 1069/2009 on animal by-products.
[49] Article 3 point 1) Reg. 1069/2009
[50] Article 3 point 2) Reg. 1069/2009
[51] Article 3 point 20) Reg. 1069/2009
[52] Article 3 point 22) Reg. 1069/2009
[53] Article 3 point 19) Reg. 1069/2009
[54] Regulation 853/2004, Annex I, point 8.1
[55] Article 8, 9 and 10

Category 2[56] includes "manure, non-mineralised guano and digestive tract content."

The method of disposal and use of materials in this Category[57] provides that these materials: b) recovered or disposed of by co-incineration, if the Category 2 material is waste:

(i) directly without prior processing; or

(ii) following processing, by pressure sterilisation if the competent authority so requires, and permanent marking of the resulting material;

(d) used for the manufacturing of organic fertilisers or soil improvers to be placed on the market in accordance with Article 32 following processing by pressure sterilisation, when applicable, and permanent marking of the resulting material;

e) composted or transformed into biogas:

(i) following processing by pressure sterilisation and permanent marking of the resulting material; or

(ii) in the case of manure, digestive tract and its content, milk, milk-based products, colostrum, eggs and egg products which the competent authority does not consider to present a risk for the spread of any serious transmissible disease, following or without prior processing;

(f) applied to land without processing, in the case of manure, digestive tract content separated from the digestive tract, milk, milk-based products and colostrum which the competent authority does not consider to present a risk for the spread of any serious transmissible disease."

Paragraph 1 of Article 32 of this Regulation sets out the availability of such products on the market:

"Organic fertilisers and soil improvers may be placed on the market and used provided:

(a) they are derived from Category 2 or Category 3 material;

(b) they have been produced in accordance with the conditions for pressure sterilisation or with other conditions to prevent risks arising to public and animal health, in accordance with the requirements laid down pursuant to Article 15 and any measures which have been laid down in accordance with paragraph 3 of this Article;

(c) they come from approved or registered establishments or plants, as applicable."

[56] Article 9, point a)
[57] Article 13

ANNEX II

Regulation 2019/1009 Article 42

Amendments of Annexes

1. The Commission is empowered to adopt delegated acts in accordance with Article 44 amending Annex I, with the exception of cadmium limit values and the definitions, or other elements relating to the scope, of product function categories, and amending Annexes II, III and IV, for the purposes of adapting those Annexes to technical progress and of facilitating internal market access and free movement for EU fertilising products:

(a) which have the potential to be the subject of significant trade on the internal market, and *(b) for which there is scientific evidence that they:*
(i) do not present a risk to human, animal or plant health, to safety or to the environment, and (ii) ensure agronomic efficiency.

When adopting delegated acts which introduce new contaminant limit values in Annex I, the Commission shall take into account scientific opinions of the European Food Safety Authority, the European Chemicals Agency or the Commission's Joint Research Centre, as relevant.

Where the Commission adopts delegated acts in order to add or review component material categories so as to include materials that can be considered to be recovered waste or by-products within the meaning of Directive 2008/98/EC, as amended by the Directive 2018/851/EC, those delegated acts shall explicitly exclude such materials from component material categories 1 and 11 of Annex II to this Regulation.

When adopting delegated acts under this paragraph, the Commission shall prioritise in particular animal byproducts, byproducts within the meaning of Directive 2008/98/EC as amended by the Directive 2018/851/EC, and recovered waste, in particular from the agricultural sector and the agro-food industry, as well as materials and products already lawfully placed on the market in one or more Member States.

2. Without undue delay after 15 July 2019, the Commission shall assess struvite, biochar and ash-based products. If that assessment concludes that the criteria in point (b) of paragraph 1 are fulfilled, the Commission shall adopt delegated acts pursuant to paragraph 1 to include those materials in Annex II.

3. The Commission may only adopt delegated acts pursuant to paragraph 1 amending Annex II to this Regulation to include in the component material categories materials that cease to be waste following a recovery operation if recovery rules in that Annex, adopted no later than the inclusion, ensure that the materials comply with the conditions laid down in Article 6 of Directive 2008/98/EC as amended by the Directive 2018/851/EC.

4. The Commission may only adopt delegated acts pursuant to paragraph 1 amending Annex II to add new microorganisms or strains of micro-organisms, or additional processing methods to the component material category for such organisms after having verified which strains of the additional micro-organism fulfil the criteria in point (b) of paragraph 1, on the basis of the following data:

...

5. The Commission may only adopt delegated acts pursuant to paragraph 1 amending Annex II to this Regulation to add derived products within the meaning of Regulation (EC) No 1069/2009 in the component material categories where an end point in the manufacturing chain has been determined in accordance with Article 5(2) of that Regulation.

The Commission shall assess such derived products with respect to relevant aspects not taken into account for the purpose of determining an end point in the manufacturing chain in accordance with Regulation (EC) No 1069/2009. If that assessment concludes that the criteria in point (b) of paragraph 1 of this Article are fulfilled, the Commission shall adopt delegated acts pursuant to paragraph 1 of this Article to include those materials in the table in component material category 10 in Part II of Annex II to this Regulation without undue delay whenever such an end point is determined.

…

8. The Commission is empowered to adopt delegated acts in accordance with Article 44 amending Annex I, with the exception of cadmium limit values, and Annexes II, III and IV in the light of new scientific evidence. The Commission shall use this empowerment where, based on a risk assessment, an amendment proves necessary to ensure that any EU fertilising product complying with the requirements of this Regulation does not, under normal conditions of use, present a risk to human, animal, or plant health, to safety or to the environment.

ANNEX III NATIONAL FUNDING TOOLS

National Funding Tools – Bosnia and Herzegovina

In Bosnia and Herzegovina, agricultural policy and rural development policy are conducted separately by entities, and therefore the elaboration of measures related to the green economy is separate for the RS and the FBiH.

The complexity of the political system and decentralization of power in Bosnia and Herzegovina (BiH) caused, according to the Dayton Peace Agreement (1995), the largest number of competencies have the institutions of the two entities, the Federation of BiH (FBiH) and the Republika Srpska (RS), and the Brcko District of BiH (BD), while through the state level and their institutions (Ministries within the Council of Ministers of BiH) coordination activities and activities related to integration affairs take place. Thus, the largest number of issues (institutional, legislative, public policy) that are in the field of green economy such as agriculture and rural development, environmental protection, natural resource management and energy efficiency are exclusively within the competence of the entities and their relevant institutions, while at the state level these issues are covered by the work of the Ministry of Foreign Trade and Economic Relations (MoFTER).

It should be noted that in BiH, due to a lack of political will, the IPARD (EU instrument for pre-accession assistance for rural development structure) has not yet been established. Although at the beginning of 2019, formal preconditions were created for the withdrawal of IPARD funds in full (a coordination mechanism was established and a Rural Development Program was developed at the level of the state of BiH), this did not happen. Instead to that, the EU decided that UNDP should implement certain grant funds for the agriculture and food processing sector through the EU4Business program. At the suggestion of the relevant institutions, UNDP tried to adjust the measures/implementation as similar as possible to IPARD, but this is still quite far from the “real measures of the IPARD program.

In the RS, the process of "greening" agriculture is at a very low level and is the result of a lack of a clear vision of the importance of this process, limited financial resources and modest institutional capacity. Rural development measures, as part of the most important measures, which should participate in the mentioned transition processes, are mainly refers to measures aimed at increasing the competitiveness of agricultural producers. These are measures of investment in physical assets in plant and animal production, while there are no measures related to the improvement of the agri-environment. These measures include support for organic production, protection of indigenous genetic resources, and support for the development of areas with limited conditions (mountain areas). Budget funds come from the MAWMF of the RS (Ministry of Agriculture, Forestry and Water Management of the Republika Srpska) and the proposed measures are based on the current Strategy for the Development of Agriculture and Rural Areas of the RS. Among other line ministries, the Ministry of Physical Planning, Construction and Ecology of RS should be mentioned, which finances various projects in the field of environment, remediation of polluted land and others, but there are no clearly defined measures that will be systematically accompanied by adequate budget transfers.

In the FBiH, the issue of rural development is contained in the Rural Development Program of the Federation of BiH (2018-2021), which unfortunately was never adopted by the Parliament, but was only verified as a document of the Government of Federation of BiH, without validity. However, on the basis of this document, the Rulebook of Rural Development of the Federation of BiH was made, which serves to create rural development measures that are in the annual programs of financial support in agriculture and rural development.

Regarding measures for support the transition to green agriculture in this BiH entity, it can be said that this process has not actually begun. Measures in the field of agri-environment do not actually exist and only a measure of support for the certification of organic production can be singled out, for the implementation of which a very small fund is allocated. All support to rural development from the level of FMAWMF (Federal Ministry of Agriculture, Water Management and Forestry) refers to capital investments and support to increase the competitiveness of the agricultural sector.

In addition to budget support provided at the entity level, cantonal line ministries of agriculture as well as local self-government units create and implement their own rural development strategies/programs. These programs are designed to address the specific needs of their farmers/communities, and are often aimed at promoting traditional local food products, rural services like rural tourism or agritourism, as well as the rational use of local natural resources. In the last few years, budget allocations from the cantonal level have been the only allocations for rural development in this BiH entity.

Among other line ministries that provide some support for "greening", mention should be made of the FBiH Ministry of Environment and Tourism, which, as in RS, finances various projects in the field of environment, land reclamation and other problems of sustainability use of natural resources. In this ministry also, there is no clear strategy that has defined measures and a permanent budget, but environmental problems are solved ad hock.

As a consequence of the mentioned facts, in BiH there is no any state strategic document that regulates the issues of sustainable development or environmental protection, as integral elements of the concept of green economy. However, there are several documents whose purpose is to regulate the mentioned issues. Activities to achieve the goals of sustainable development in BiH are a continuous task that affects all elements of society, especially through the process of Euro-Atlantic integration. Thus, BiH is committed to the implementation of the Millennium development goals, and in addition, several documents related to sustainable development have been developed, such as the one prepared with the Johannesburg Summit (2002) or the document entitled BiH in the Rio + process (2012).

The concept of green economy as a concept of integrated economic, social and environmental issues and activities in the form of a sustainable economy in both BiH entities, the FBiH and the RS have not yet begun. In none of the BiH entities is there a strategic and legal framework that would have an integrated development policy in the field of green economy, and in fact the practical implementation of green economy segments is at the very beginning.

Entity strategies and programs in the FBiH and the RS do not directly address green economy issues, nor is there a comprehensive policy framework in both BiH entities to address sustainable needs. green economy. However, analysing a number of strategic and program documents in both BiH entities related to different sectors (agriculture, rural development, economy in general, energy sector, environmental protection, etc.) there is a "green" transition in the field of policy, legislation or institutions with different levels of success and different levels of intensity.

Although in BiH and its entities there is a significant number of documents that are in line with the harmonization of policy and legislative framework with EU standards such as climate change and CO2 emissions, environmental protection and waste management, land, air and water protection, it is still weak, and the implementation of existing policies and regulations is insufficient and without adapted mechanisms (taking into account the EU standards) for successful functioning.

The FBiH and the RS face a number of challenges related to the use of cleaner energy, energy efficiency, adaptation to climate change, management and control of pollution (especially air) that significantly harm the economy and the population. The general impression is that there is more declarative talk about the importance of these challenges, without doing anything to address them. This is supported by the beginning of the construction of a new thermal power plant in the FBiH (Tuzla) as well as minor activities related to the prevention of high air pollution, which makes BiH cities, in the winter, at the very top of the world scale.

Taking into account the context of the green economy in both BiH entities, there are very few measures that address environmental issues (2nd axis of rural development policy) and natural resource management. In the FBiH, only organic production (certification) is supported, while in the RS the list of measures is somewhat broader (organic production, protection of indigenous genetic resources, support for the development of mountain areas). What both entities have in common is that budget allocations are very modest and insufficient. The current rural development policy is mainly related to strengthening the competitiveness of agriculture (investments in physical assets), while measures to address environmental issues are practically neglected.

Funding of measures and activities that are in the context of the green economy in the agricultural sector come from entity budgets. In the Federation of BiH, funding is additionally provided from the cantonal level with significant oscillations from canton to canton. Unfortunately, in BiH, due to the lack of political will, IPARD funds were not activated, although in 2019 certain means from this fund were implemented, but not through BiH institutions, but through UNDP. Additional funding that is in line with the green economy in both BiH entities are the Ministries of Environment, as well as Environmental protection funds, but they are not implemented through systemic measures just in the form of projects through public calls.

Re-Live Waste

LIFE CYCLE ASSESSMENT

Data Inventory

click the links below or follow the tabs

Input end Output Data from process units

Waste Analysis

Struvite Analysis

Project co-financed by the European Regional Development Fund

Project co-financed by the European Regional Development Fund

Completed by:	Faruk Cerić	**Date completed:**	18.11.2020.
Reporting location:	Agriculture farm Butmir		
Time period:	**Starting:** 30.11.2020.		**Ending: 03.12.2020.**

Complete a separte table for each of the system process units, copy and paste table below as required!

	Units	Quantity/ year		Units	Quantity/ year
Sludge treated	m3	3,3 per testing	**Struvite produced**		

Description of unit process: (attach additional sheet if required)					**Notes (please add notes, comments etc)**
Chemicals and Material inputs	**Units**	**Quantity/ year**	**Description of sampling procedures if measured**	**Origin of data if calculated/estimated**	*For example, Livestock waste treated, NaOH, MgCl2*
Phosphoric acid (H3PO4), 75% degree of purity	L	10.5	*Quantity of reagentses is calculated on the basic of chemical values of centrate. Calculation is done by SERECO. Quantity is calculated per bach=3,3 m3.*	*Calculated according to chemical composition of centrate (liquid part after the centrifuge), for quantity of 3,3 m3. Calculation is done by SERECO.*	On farm Butmir during the testing, we were producing centrate (liquid part from manure) 3 days before testing and then we would do analyses of chemical composition of centrate. Values of chemical composition we send to SERECO, and they calculate amount of each reagents for quantity of 3,3 m3.
Sodium hydroxide (NaOH), 50% degree of purity	L	36			
Magnesium chloride (MgCl2) from 51% degree of purity	L	7.6			
Water consumption	**Units**	**Quantity/ year**	**Description of sampling procedures if measured**	**Origin of data if calculated/estimated**	*For example, surface water, drinking water.*
n/a					*We didn`t use any clean water for production of STRUVITE.*
Energy inputs	**Units**	**Quantity/ year**	**Description of sampling procedures if measured**	**Origin of data if calculated/estimated**	*For example, heavy fuel oil, medium fuel oil, light fuel oil, kerosene, gasoline, natural gas, propane, coal, biomass, grid electricity.*
Mixers (2 mixers, each with power 11 kW)	kW				*For each testing were working for 40 minutes on homogenisation of manure and waste water in mixing tank)*
Pump for feeding separator (1 pump, power 7,5 kW)	kW				*For each testing pump were working for 30 minutes for feeding the separator with mixed material.*
Separator (1 separator, power 4 kW)	kW				*For each testing were working for 30 minutes for separating 3,3 m3 of dry and liquid fragment of manure)*
Dosing units (3 pumps for introduction of reagents, each pump is 58 W). Accroding to quantity pof reagents that need to be introduced, each pump was working in diferent time. Time is:	W				
Dosing pump for Phosphoric acid - were working 1h and 5 minutes	W				
Dosing pump for Sodium hydroxide - 3 h	W				
Dosing pump for Magnesium chloride - were working 10 minutes	W				
Pump for transport of centrate with reagentes to the bags 1,6 kW, pump were working for 24 minutes	kW				
Transport	**Units**	**Quantity/ year**	**Description of sampling procedures if measured**	**Origin of data if calculated/estimated**	*For example, number of kilometres, type of vehicle and fuel*
Transport with buldozer- 2m3 in one circle (sables form pilot plant are 200m)	m3				*Daily production of manure is about 30 m3. Bulldozer needs to make 15 laps from stable to pilot plant to transport all manure in mixing tank.*
Material outputs	**Units**	**Quantity/ year**	**Description of sampling procedures if measured**	**Origin of data if calculated/estimated**	*For example, sludge, struvite, effluent*
(insert lines if required)					

Complete a separte table if more analysis from different waste batches are available, copy and paste table below as required!

Composition of livestock waste to be treated for testing on 3.12.2020.			
Parameter	**Units**	**Quantity**	**Protocol (if known)**
pH		7.11	
TS		-	
COD		-	
NH3-N	mg/L	580	
N-tot	mg/L	1750	
P-tot		-	
Hg		-	
Cd		-	
Pb		-	
Cu		-	
Zn		-	
PAH		-	
PCB		-	
Na	mg/L	712	
Conductivity		-	
TDS		-	
TSS (Total Suspended Solids)		-	
VSS (Volatile Suspended Solids)		-	
TVS	%	4.54	
Ca2+	mg/L	811	
Mg2+	mg/L	321	
K+	mg/L	1123	
P-PO43-	mg/L	237	
TKN			
SO42-			
Cl-	mg/L	4.89	
Total Alkalinity			

Composition of livestock waste to be treated for testing on 10.12.2020.			
Parameter	**Units**	**Quantity**	**Protocol (if known)**
pH		7.62	
TS		-	
COD		-	
NH3-N	mg/L	923	
N-tot	mg/L		
P-tot		-	
Hg		-	
Cd		-	
Pb		-	
Cu		-	
Zn		-	
PAH		-	
PCB		-	
Na	mg/L	302	
Conductivity		-	
TDS		-	
TSS (Total Suspended Solids)		-	
VSS (Volatile Suspended Solids)		-	
TVS	%	4.97	
Ca2+	mg/L	1068	
Mg2+	mg/L	510	
K+	mg/L	1059	
P-PO43-	mg/L	629	
TKN		-	
SO42-		-	
Cl-	mg/L	1.31	
Total Alkalinity			

Complete a separte table if more analysis from different struvite batches are available, copy and paste table below as required!

Struvite chemical composition form testing 03.12.2020.			
Parameter	**Units**	**Quantity**	**Protocol (if known)**
MgO	%	0.55	
PO4 3-		10.08	
NH4+	%	1.59	
CaO	%	1.12	
SiO2		-	
H2O		-	
Fe		-	
Na2O		0.99	
K2O		0.92	
TS		-	
Organic carbon	%	23.2	
Organic Matter	%	-	
N-tot		-	
P-tot		4.75	
Hg		-	
Cd		<0,4	
Cr VI		-	
Ni		<0,4	
Pb		<10	
As		-	
Cu		24.9	
Zn		171	
Zr		-	
Mn			
Struvite-Pathogens			
Parameter	**Units**	**Quantity**	**Protocol (if known)**
Salmonella spp.			
Escherichia coli or Enterococcaceae			

Struvite chemical composition form testing 10.12.2020.			
Parameter	**Units**	**Quantity**	**Protocol (if known)**
MgO	%	0.44	
PO4 3-		8.25	
NH4+	%	1.08	
CaO	%	1.27	
SiO2		-	
H2O		-	
Fe		-	
Na2O		1.18	
K2O		1.02	
TS		-	
Organic carbon	%	26.6	
Organic Matter	%	-	
N-tot		-	
P-tot		4.4	
Hg		-	
Cd		<0,4	
Cr VI		-	
Ni		<0,4	
Pb		<10	
As		-	
Cu		19.3	
Zn		157	
Zr		-	
Mn			
Struvite-Pathogens			
Parameter	**Units**	**Quantity**	**Protocol (if known)**
Salmonella spp.	CFU/ml	150	
Escherichia coli or Enterococcaceae	in 25 g	non detected	
Ascaris eggs	N_o in 100 g	426	
Spore-forming bacteria (spores of sulphite reducing clostridiClostridium)		non detected	

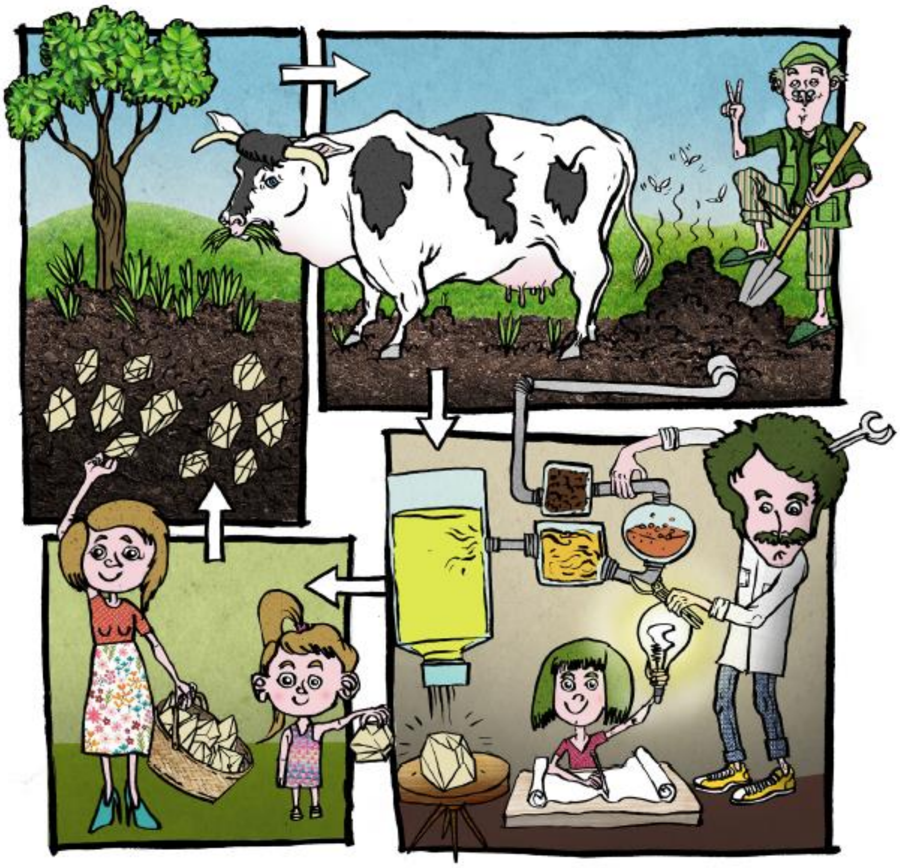
COMIC STRIP

Interreg Mediterranean RE-LIVE WASTE

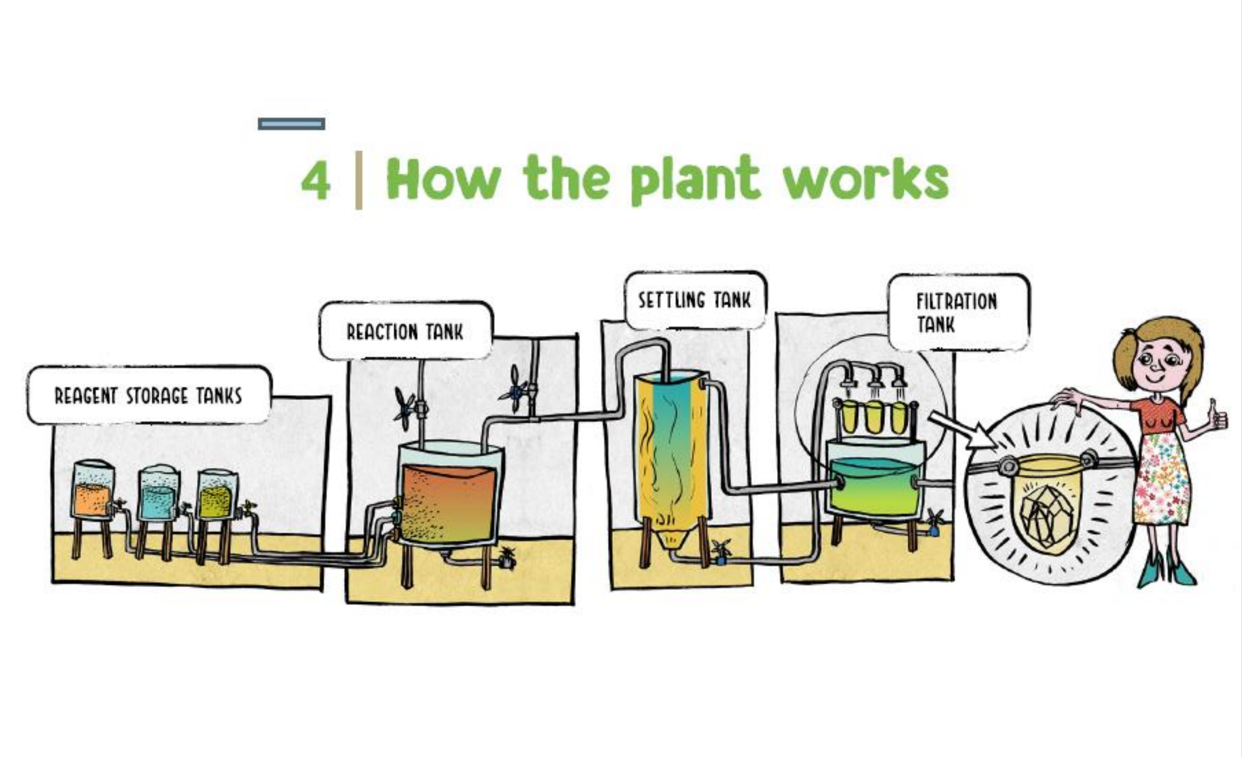
la famiglia DE VERDIS

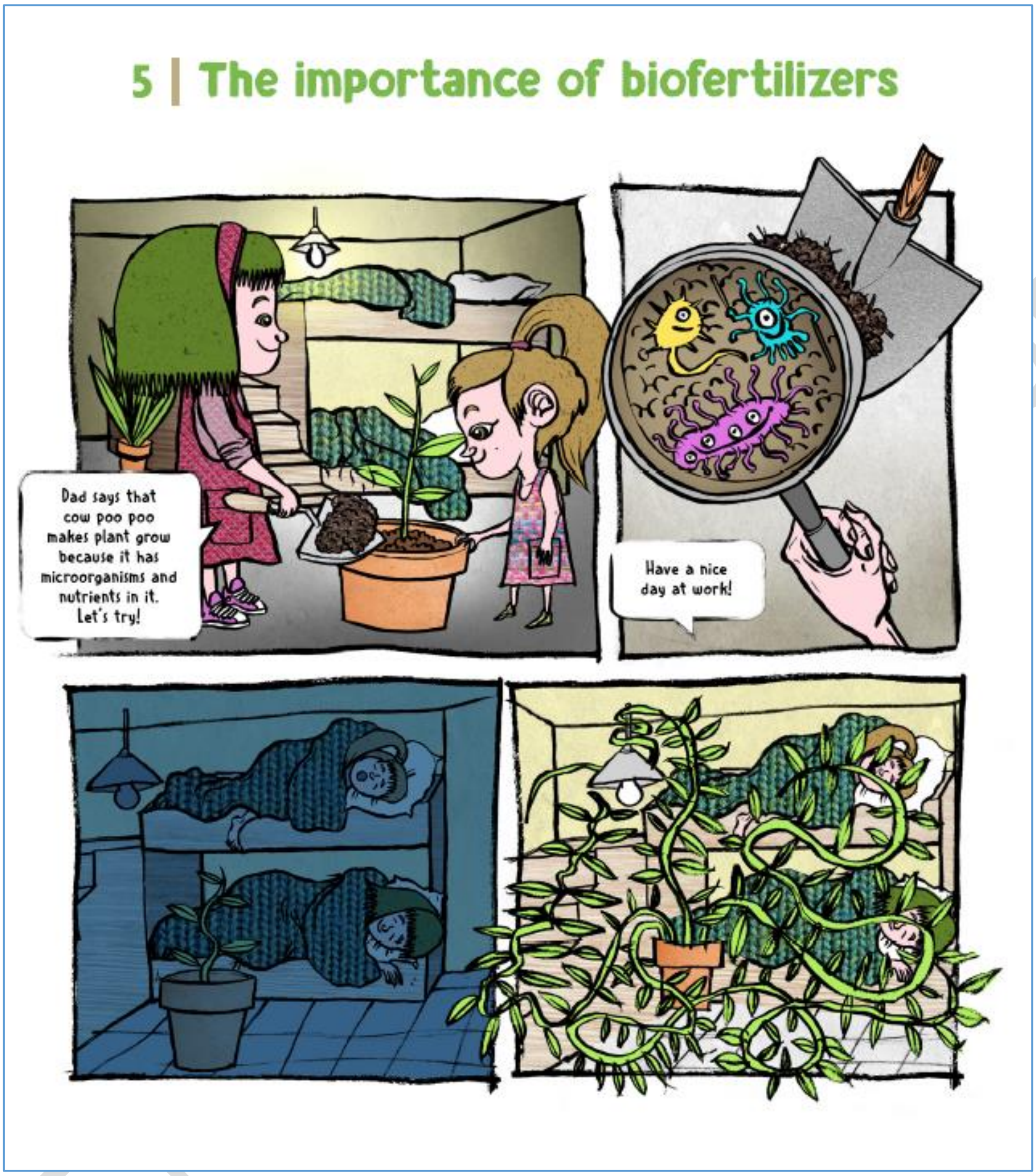
1 | What is struvite?

2 | Circular economy



3 | The EU Nitrates Directive

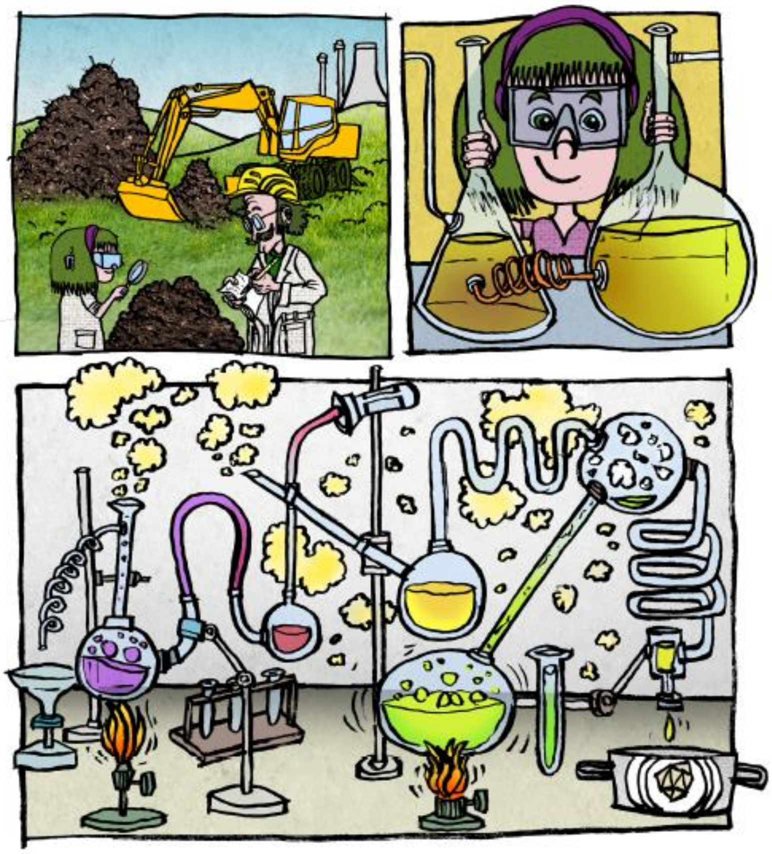

4 | How the plant works
REAGENT STORAGE TANKS
REACTION TANK
SETTLING TANK
FILTRATION TANK


5 | The importance of biofertilizers
Dad says that cow poo poo makes plant grow because it has microorganisms and nutrients in it. Let's try!
Have a nice day at work!

6 | Green Growth Community

7 | Not waste, but resources

8 | The role of labs




9 | The role of policymakers
BRUXELLES

10 | The role of farmers