Società Agricola
Assoro Biometano

Digestate production and fertirrigation distribution: the proficuous recycle of water and nutrients through anaerobic digestion of agrifood waste - an Italian case study

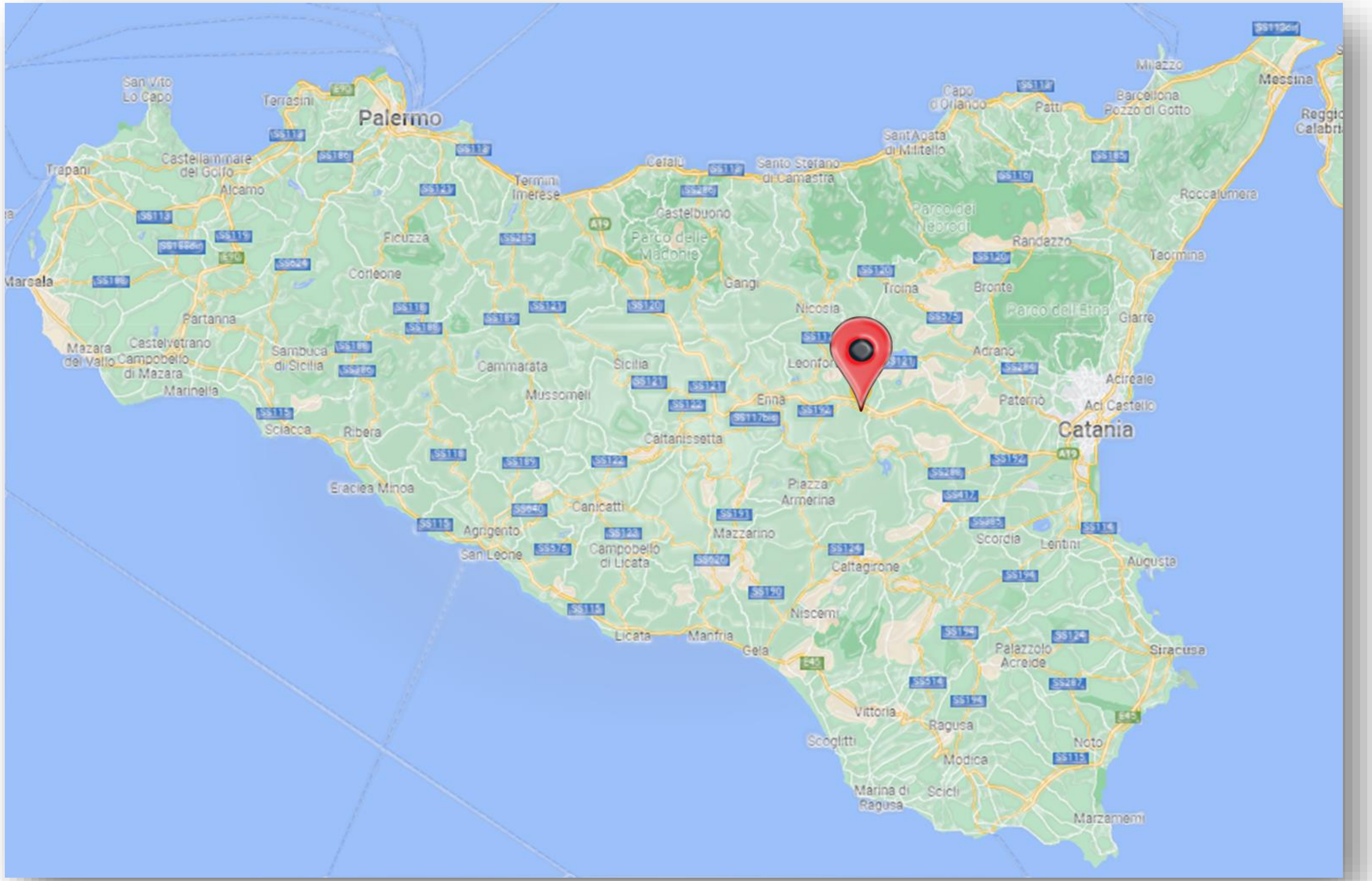
ROBERTA SELVAGGI
sostenibilita@assorobiometano.it

27th April 2023

GBEP WEBINAR SERIES 2023
Co-benefits of biogas and biomethane

Where we are

Dittaino Valley, Assoro (EN) - Sicily, Italy
You can find us on Google Maps under our name! – And on Facebook & LinkedIn as well -



LinkedIn: Società Agricola Assoro Biometano S.r.l.
linkedin.com/company/assorobiometano/

Facebook: Società Agricola Assoro Biometano
facebook.com/assorobiometano

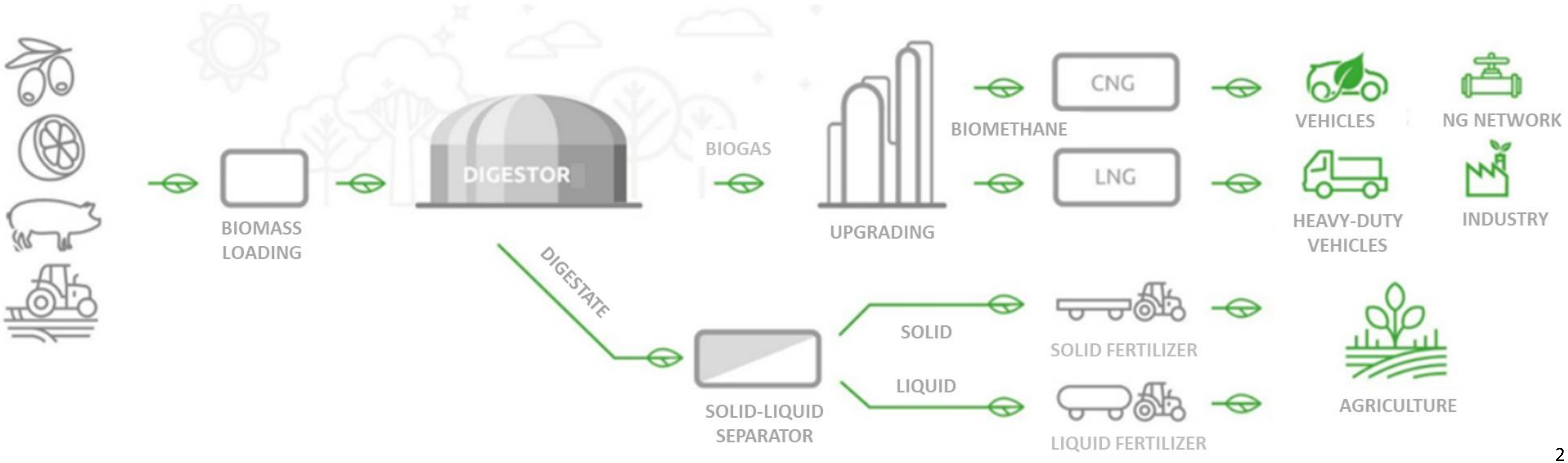
Operational Aspects

Biomasses: Agroindustrial residues and livestocks effluents

Anaerobic Digestion: Wet (TS < 10%) + Mesophilic (T = 38-40 °C) + Covered Storage (HRT = 100d)

Upgrading: Pressure Swing Adsorption (PSA) with offgas < 2.0%CH_4

Biomethane: Compressed + Liquefied



Biomasses Characteristics

- ✓ Only agro-industrial residues (no waste is used!)
- ✓ Local (< 50km)
- ✓ Suitable for advance biofuel production (DIRECTIVE 2018/2001)
- ✓ Mostly liquid (< 10%TS) & semi-solid (< 30%TS)
- ✓ High biomethane yield
- ✓ High nutrient load (NPK)
- ✓ Partialy inhibitory for AD

Chicken manure

Orange peelings

Olive pomace

Olive oil wastewater

Mass balance

Input

Biomass	**Quantity (t/y)**
Citrus pulps + Wastewater	32.000
Olive Pomace + Wastewater	18.000
Poultry litter + Laying Hens Manure	20.000
Pig Slurry	4.000
Other	500
Rain Water	4.500
TOTAL	**79.000**

Output

Biogas	**Quantity (Sm^3/y)**
Biomethane (CH_4)	4.400.000
Off-gas (CO_2)	2.900.000

Digestate	**Quantity (m^3/y or t/y)**
Raw	70.000
Liquid	59.500
Solid	10.500

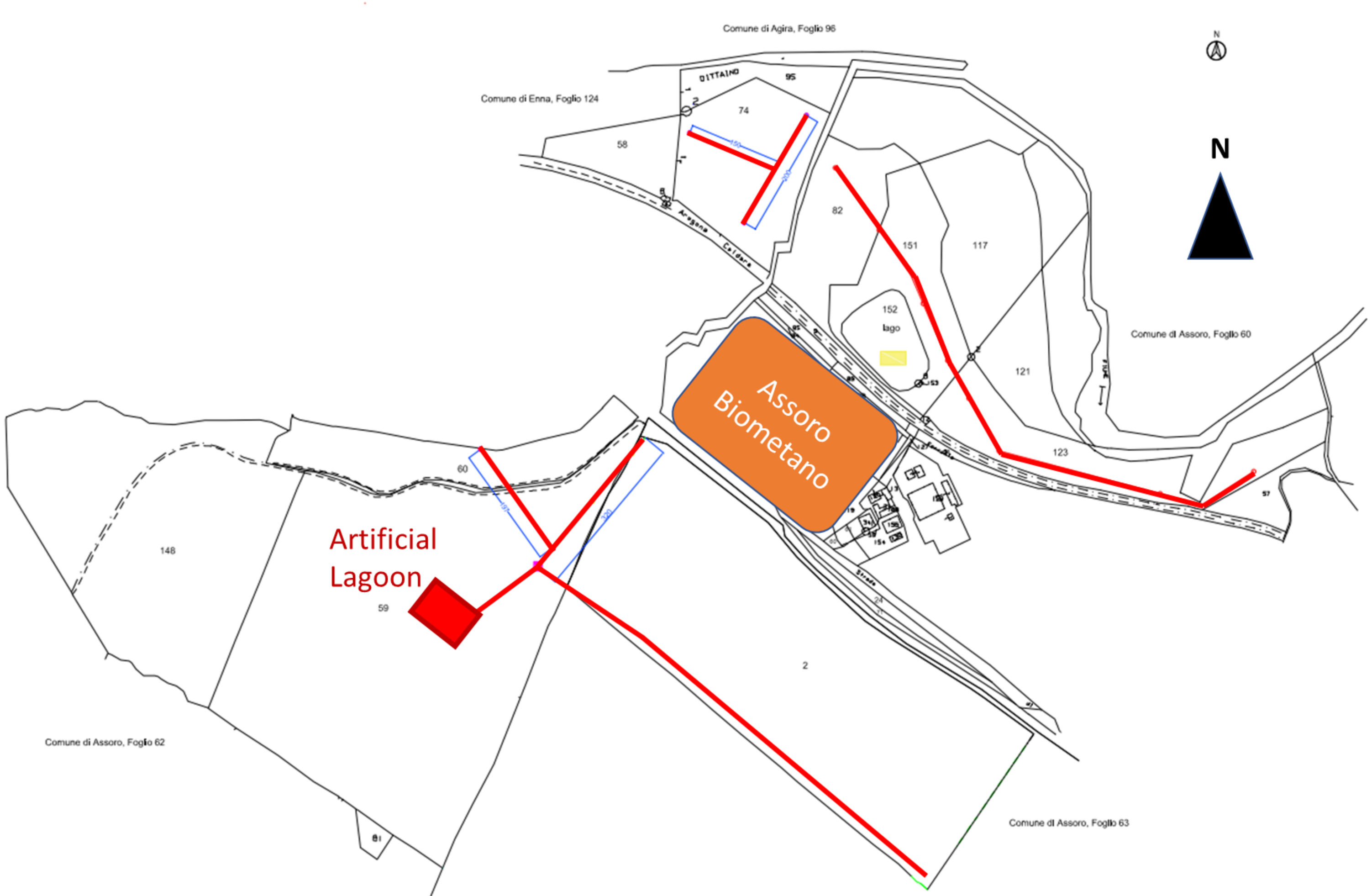
Biomethane Production

- Local Biomethane Supply (< 100km)
- The production of **4,4 million Sm^3/y of advance biomethane** is equivalent to:
  - more than 74 million driven km by a methane-fueled vehicle;
  - the total fuel of 3.000 methane-fueled vehicles in a year; or
  - 3.400 t of oil equivalent (toe).

And <u>a saving of 8.580t of fossil-derived CO_2 emissions</u>

Digestate Composition & Spreading

Parameters	Digestate			Units
	Raw	Liquid fraction	Solid Fraction	
pH	8,2	8,5	8,7	*(-)*
TS	55,8	43,6	229,3	*(kg/t)*
VS	62,6	60,7	86,0	*(%TS)*
NTK	6,2	3,5	8,3	*(kg/t)*
P	1,5	1,3	2,6	*(kg/t)*
K	4,5	4,5	4,6	*(kg/t)*



Irrigation network and tubing for liquid fraction digestate

Agricultural soil composition for Assoro Biometano (Summer 2020)

	Sand %	Silt %	Clay %	pH	Limestone tot %	O.M. %	Nitrogen ‰	C/N	CEC meq/100g	P_2O_5 ass ppm	K_2O scamb ppm	Sodium ppm	Calcium ppm	Magnessium ppm
MIN	0,5	29,9	13,3	7,1	5,8	0,6	0,3	7,1	10,5	5,8	127,4	44	1402	218
MAX	40,7	62,1	59,0	8,0	106,1	3,6	2,1	14,3	35,6	110,1	870,7	1320	5832	1306
MEDIA	13,8	40,5	45,7	7,5	13,6	1,3	0,8	9,5	28,4	26,8	508,8	217	4364	551
DEV.ST	6,9	5,1	7,5	0,2	15,0	0,6	0,3	1,6	3,8	23,3	127,6	204	915	227

	Iron ppm	Copper ppm	Zinc ppm	Manganesse ppm	Boron ppm
MIN	8,6	1,8	0,3	11,9	0,33
MAX	27,7	3,6	8,2	42,6	4,42
MEDIA	17,3	2,6	1,2	24,9	1,66
DEV.ST	4,7	0,5	1,9	5,6	1,18

High Risk of Desertification!

The Benefits of Digestate

- ✓ Soil organic carbon enhancement
- ✓ Natural NPK fertilization
- ✓ Microelements addition
- ✓ Pathogen & odour minimization (Vs effluents)
- ✓ Humidity retention
- ✓ Salinity intrussion avoidance

Soil fertility restoration!

Average	pH	Limestone	O.M.	N	C/N	CEC	P_2O_5	K_2O	Na	Ca	Mg
Units		%	%	‰		meq/100g	ass. ppm	exch. ppm	ppm	ppm	ppm
2020	7,5	13,6	1,3	0,8	9,5	28,4	26,8	508,8	217	4364	551
2022	7,7	21,7	1,7	1,2	8,0	32,9	38,7	722,7	279	5072	579

Not far from Dittaino Valley…
solid digestate for citrus orchards

With manure spreader wagon with two rear counter-rotating rotors

And also…
solid digestate for vineyard

With manure spreader with disc for scatter distribution

With modified manure spreader for localized distribution

Research activities: FERTIMED project

Assoro Biometano is not a «direct actor» but is near to the activities of this working group!!

Sustainable and innovative soil improvers for Mediterranean crops

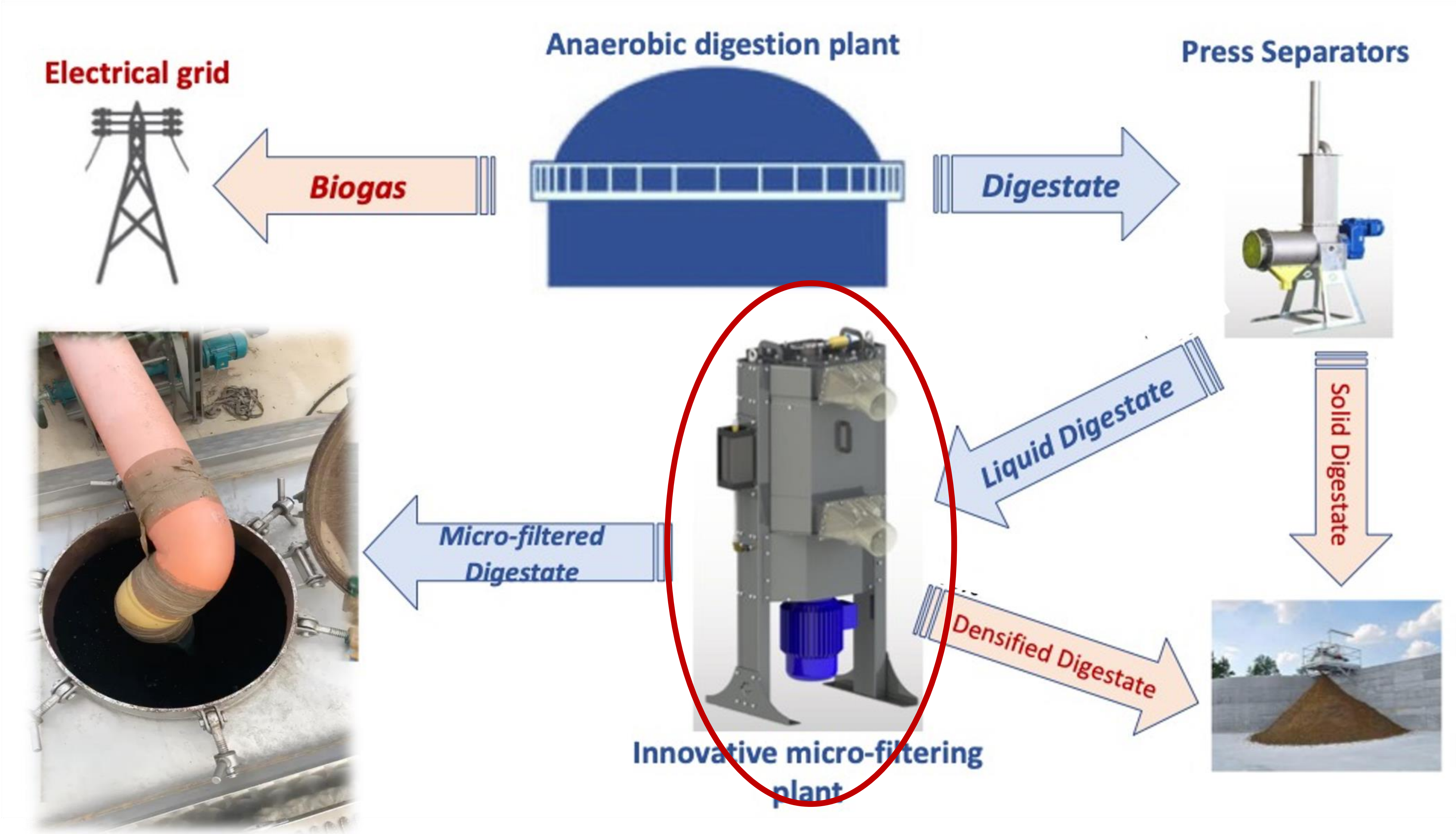
Operational Group: DIGESTATO

Funded by the Measure 16.1 of Sicily Rural Development Program 2014-2022

8 Partners involved for a **EIP-AGRI network** project with the **AIM** to evaluate technical and economic feasibility of the use of **micro-filtered digestate** in farms with permanent crops (Citrus and Opuntia spp).

Still in progress!!

Rationale of FERTIMED project



Fertigation system for micro-filtered digestate

Microfilter

Transport

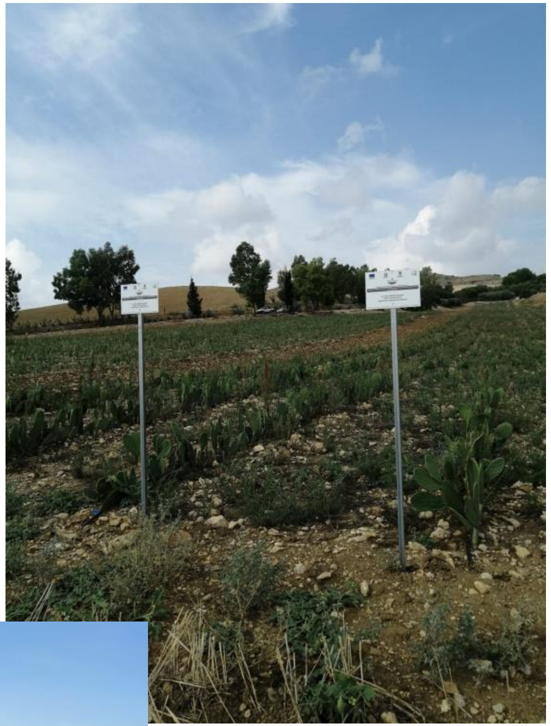
Storage tanks

Collection and measurement

Fertigation system (water + digestate)

Dripline

Crops envolved for experimental trials with micro-filtered digestate



Società Agricola Assoro Biometano

ROBERTA SELVAGGI
sostenibilita@assorobiometano.it

27th April 2023

GBEP WEBINAR SERIES 2023
Co-benefits of biogas and biomethane

Webinar **GBEP**

Co-benefits of biogas and biomethane
Digestate: a nature-based solution to optimize the water-energy-food nexus in agrifood systems

EOM4SOIL: a new EU project to evaluate the use of soil amendment in agriculture

CREA Research Centre for Agricultural Policies and Bioeconomy, Rome, Italy

EJP SOIL
European Joint Programme

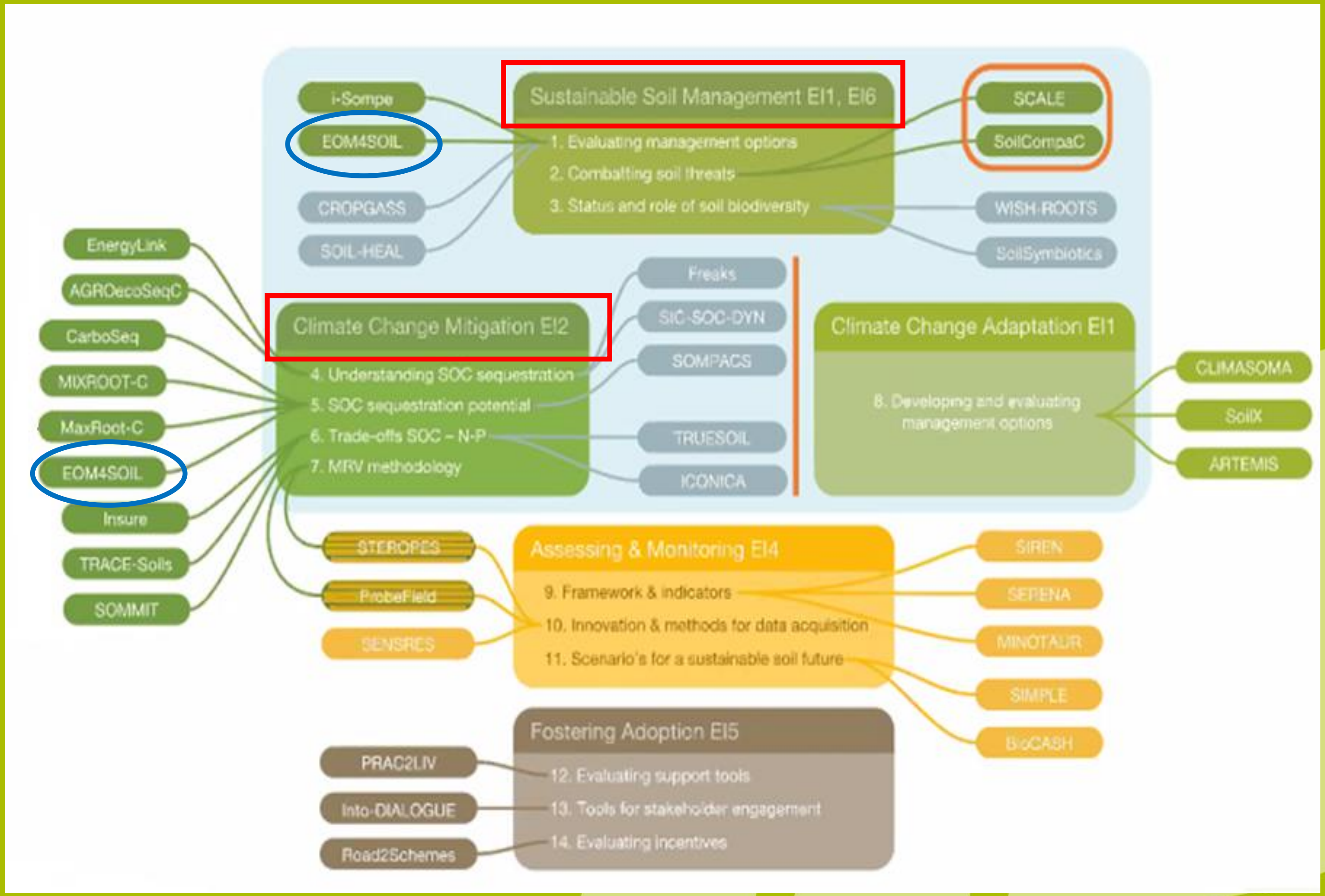
EJP SOIL has received funding from the European Union's Horizon 2020 research and innovation programme: Grant agreement No 862695

Maria Valentina Lasorella Ph.D

17 April 2023

EJP SOIL RESEARCH PROJECTS

Within the European Joint Programme on Soil, CREA is running several projects; EOM4SOIL **“External organic matters for climate mitigation and soil health”** aims to identify the best management practices that add organic matter to the soil, in particular to evaluate the use of soil amendment in agriculture.



EJP SOIL
European Joint Programme

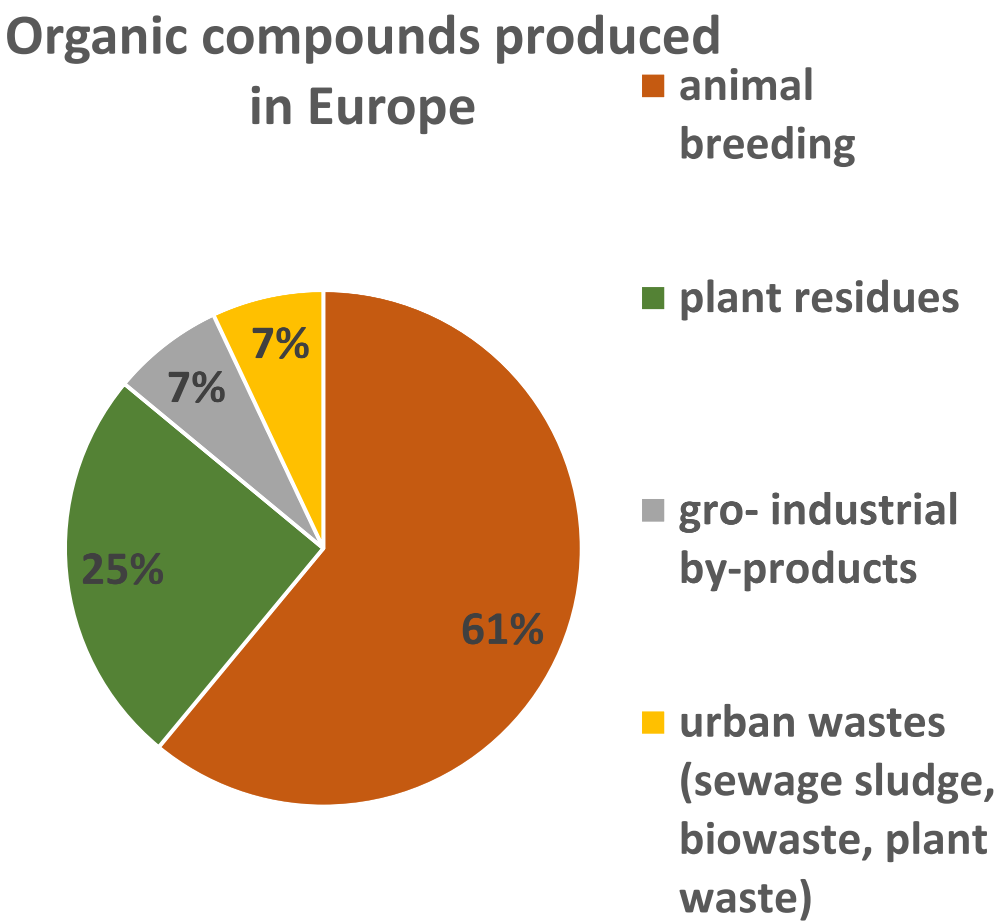
EJP SOIL has received funding from the European Union's Horizon 2020 research and innovation programme: Grant agreement No 862695

European Context for EOM4SOIL- Organic compounds produced in Europe

Many activities generate organic wastes, (from municipial, industry and agriculture).

The annual production of biowaste in the European Union is estimated at 1.6 billion tons, of which 61% are wastes produced by animal breeding, 25% originates from plant residues, 7% are industrial wastes and 7% are municipal wastes (sewage sludge, biowaste, plant waste).

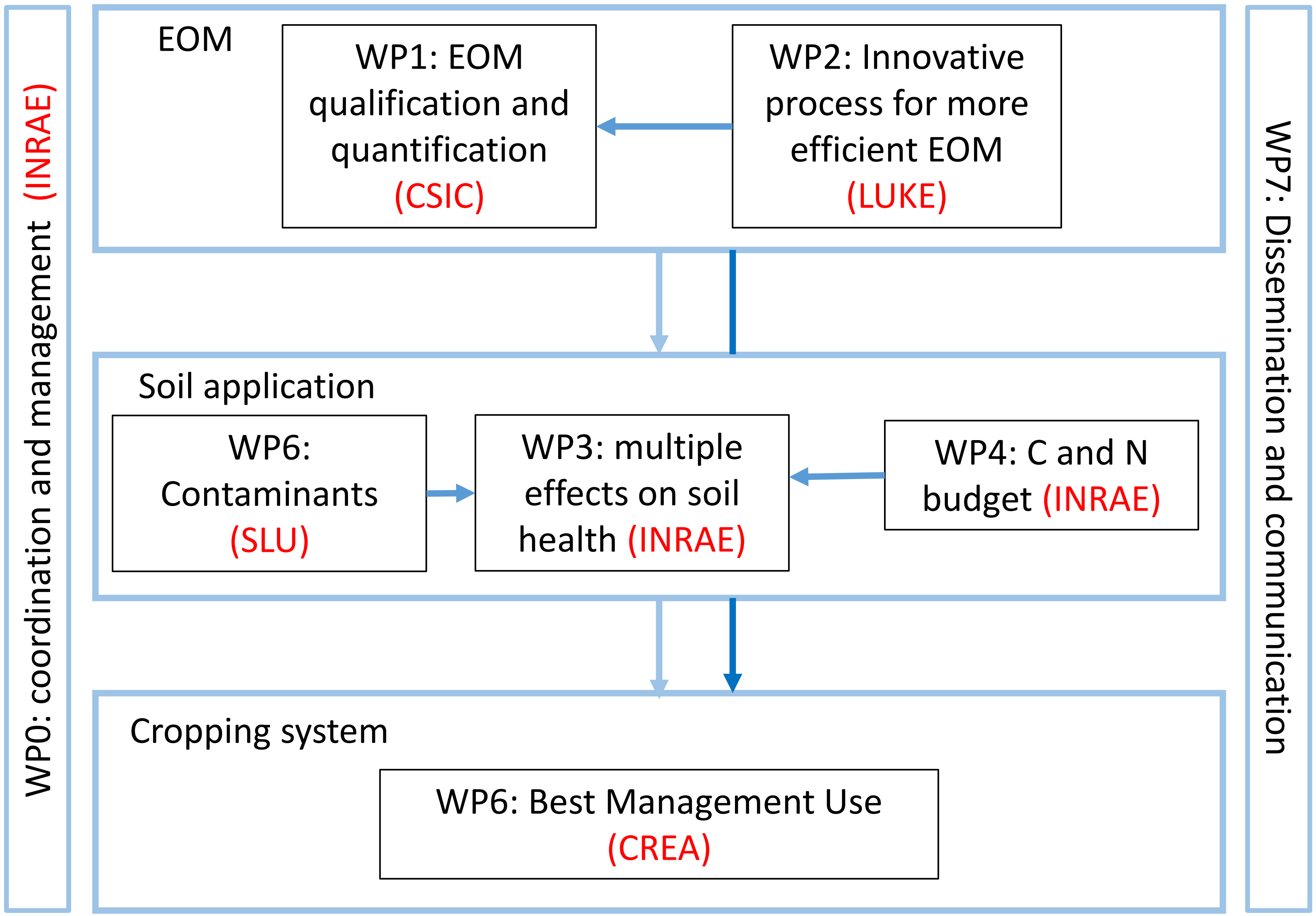
40% of biowastes in Europe are processed through treatments such as composting or anaerobic digestion; in this way, the wastes become resources.



Source: Gryta et al., 2020

EJP SOIL
European Joint Programme

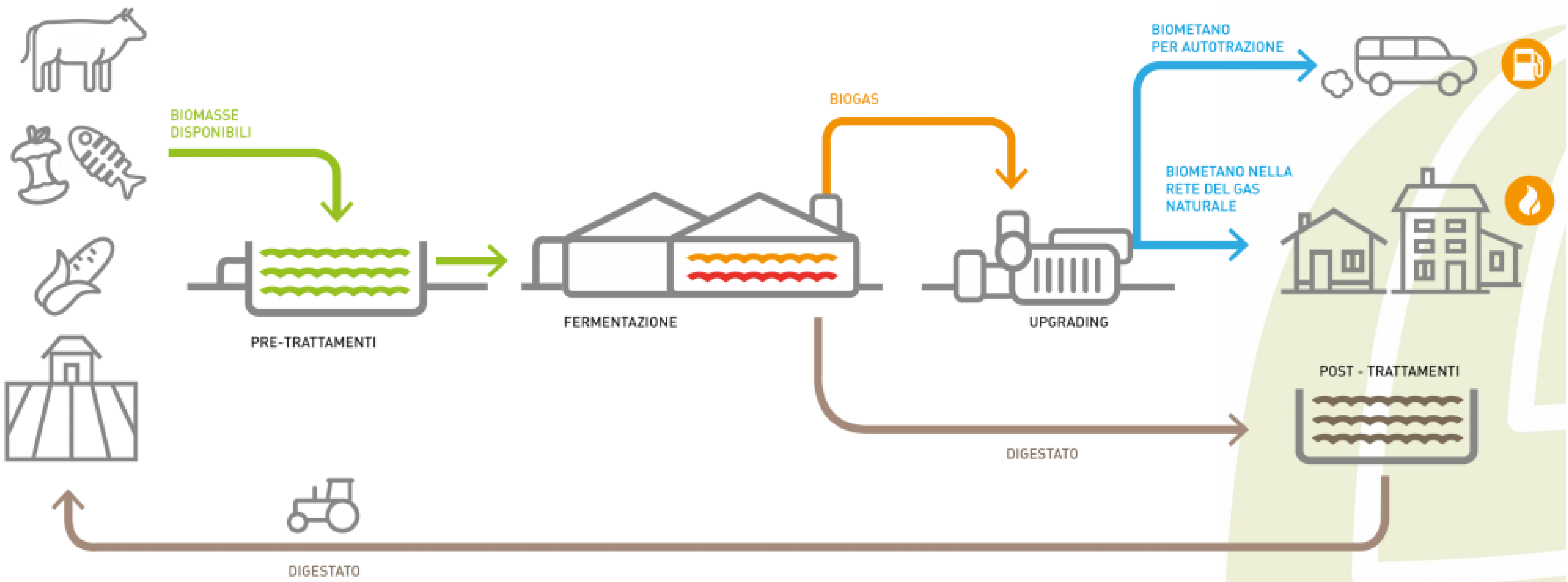
EOM4SOIL – PROJECT CONSORTIUM



"EOM4SOIL", is a three-year Horizon 2020 grant project which involves a consortium of scientific institutions from various EU Member States (Italy, France, Wallonia in Belgium, Denmark, Finland , Lithuania, Sweden, Austria and Spain) as well as Switzerland and Turkey.

The EOM4SOIL project includes 3 main parts:

- EOMs selection, qualification and characterization;
- Effects of EOM application on soils;
- Policy recommendations for best use of EOM, including the best choice of EOM and their use in farming systems)



EJP SOIL
European Joint Programme

Preliminary findings: EOMs selection, qualification and characterization

As CREA we are currently analysing the following EOMs:

- ❖Compost (main product of the process)
- ❖Digestate (by-product of the biogas-biomethane process),
- ❖Biochar (by-product of pyrolysis process)

EJP SOIL
European Joint Programme

Preliminary findings in Italy: EOMs selection, qualification and characterization

Digestate

Biogas plants: 1.730 in the agricultural sector and 470 in the waste and sewage sludge sector, mainly in Emilia-Romagna, Veneto and Lombardy Regions.

Average diet of digestate production: 62% cattle, poultry slurry and manure; 30% silage crops and 8% agro-industrial by-products)

Producing around **3 million tons of digestate.**

Source: CRPA and CIB, 2022

Compost

Biowaste production : 7.387.000 tons

Compost production:

Mixed 1.143.000 tons
Green 517.000 tons
Mixed with sewage sludge: 426.000 tons

Total 2.086.000 ton

Compost technology

Composting 62%

Anaerobic digestion/composting 38%

Source: ISPRA, 2021, CREA-VE, 2022)

Biochar

Biochar production:

6 companies are currently producing **wood-chips biochar**,

5 companies deal with its **packaging and distribution** (biochar producers authorized by the Ministry of agriculture).

syngas for power or heat production.

The **annual national production** is **around 1,000 t** with different physico-chemical characteristics.

Source: CREA-PB 2022, Ministry of agriculture

National and EU policies related to EOMs

Global strategies for sustainable development in the framework of climate change

UN Framework Convention on Climate Change

UNCCD 2018–2030 Strategic Framework

UN Sustainable Development Goals

EU policy framework on EOMs production, market and use

- EOMs in the EU strategies to achieve climate pledges
  - European Green Deal
    - e.g., Farm to Fork; Fit for 55%; C-farming and C stock; …
- EU P&Ms to achieve the goals set in EU strategies
  - Common Agricultural Policy
    - Support to voluntary standards/certifications
- Regulatory framework: requirements/rules for EOMs use – Sectoral compliance
  - EU Regulation 2019/1009 on Fertilizers
  - National laws on fertilizers and soil amendments
- Context related restrictions – Territorial compliance
  - Nitrate Directive
  - Water Directive

EJP SOIL
European Joint Programme

Work in progress!!!

- What are the **most promising** and **suitable types of EOM** and what are the available amendments for **application to soil** in EU?........compost, digestate, biochar, etc..

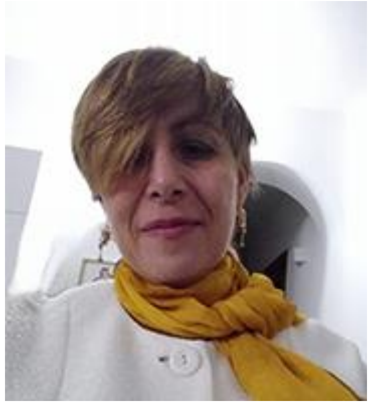
- Which are the conditions that make **EOM's production process sustainable**, from economic, environmental and social points of view? … a list of indicators shall be identified….

- Which are the existing **EU policy framework** in relation to EOMs production and application to soil? **working on policy recommendation** aiming at **fostering the development of sustainable EOMs pathways** that can contribute to achieve the targets set out by the EU Green Deal and other EU policies

Thanks for your attention!

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria








Council for Agricultural Research and Economics
Research Centre for Agricultural Policies and Bioeconomy

Contact us:
mvalentina.lasorella@crea.gov.it
assunta.amato@crea.gov.it
francesca.varia@crea.gov.it
ilaria.falconi@crea.gov.it
francesco.galioto@crea.gov.it
daniela.quarato@crea.gov.it
giovanni.daraguccione@crea.gov.it
Irene.criscuoli@crea.gov.it

WEBSITE - https://ejpsoil.eu/soil-research/eom4soil

GBEP WEBINAR SERIES 2023

Co-benefits of biogas and biomethane

Digestate: a nature-based solution to optimize the water-energy-food nexus in agrifood systems

“High solids and wet anaerobic digestion potential for the treatment of the organic fraction of municipal solid waste: A case study in Brazil”

Dr. Rodolfo Daniel Silva Martínez

Advisor: Dr. Alessandro Sanches Pereira
Co-advisors: Prof. Dr. Suani Teixeira Coelho
Prof. Dr. Antonio Sampaio Baptista

University of São Paulo

27/04/2023

Outline

I. Introduction
- State of the art
- Problem statement
- Anaerobic digestion

II. Objectives and methods
- Purpose of the research
- Methodology
- Objects under investigation

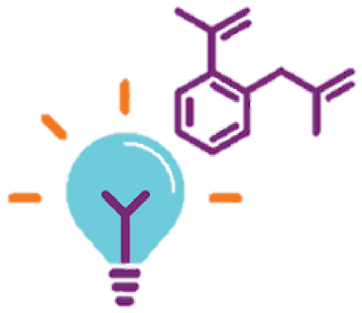
III. Results
- Mass flow and nutrient balance
- Energy balance
- Emissions and global warming

IV. Key findings and conclusions

V. References

I. Introduction

Introduction & State of the art



- In Brazil, ***anaerobic digestion*** technologies have been implemented, yet there is still a long way to significantly contribute to suffice waste treatment, ***fertilizers,*** and energy needs.

- The ***organic fraction of municipal solid waste (OFMSW)*** and ***agricultural residues*** are until now a pollution source and not sufficiently recognized as valuable resources, with significant energy and ***nutrient potential***.

- ***High solid anaerobic digestion (HSAD)*** is a promising alternative for the adequate treatment of OFMSW considering the benefits it offers.

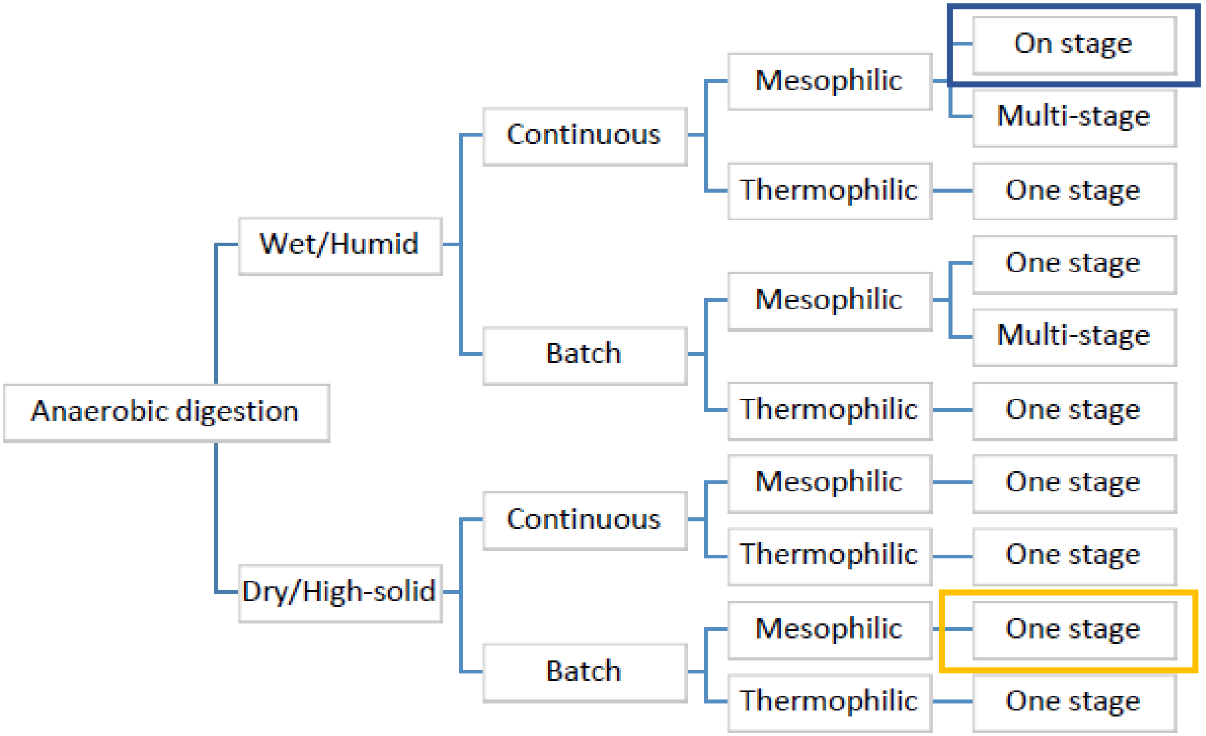
- There are a few remarkable ***HSAD*** projects, and these technologies have been lately calling the attention of researchers and policymakers.

- The applicability of ***large-scale HSAD technologies*** for treating organic residues is under development and remains to be demonstrated.

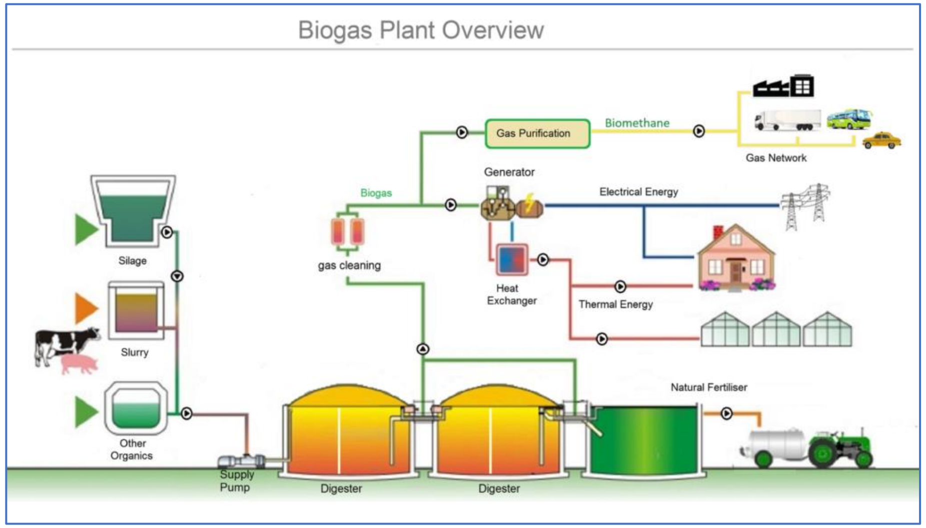
Why do we need these technologies?
Problem Statement

- The proliferation of municipal and agricultural ***wastes***, provoking health and environmental issues (e.g. watershed contamination, pests, disease transmissions, etc.);
- ***Water*** scarcity issues in some regions;
- The continuing increase of ***energy*** consumption (fuels and electricity) rates and demand;
- Supply of large amounts of artificial ***fertilizers*** in agriculture.
- Dependence on fossil fuels & large ***GHG emissions***.
- ***Linear economic practices***, where resources are not revalued.

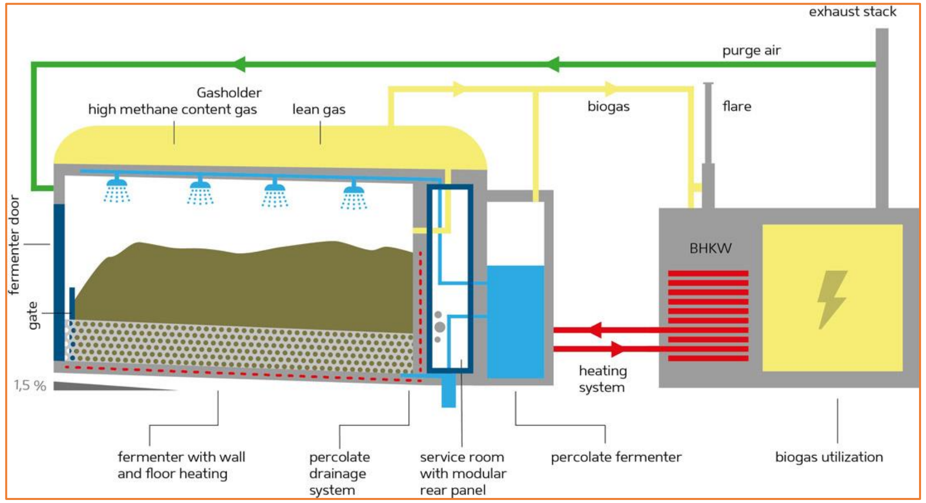
Types of AD reactors



General classification of AD types. Source: [1]



Source: (2)



Source: (3)

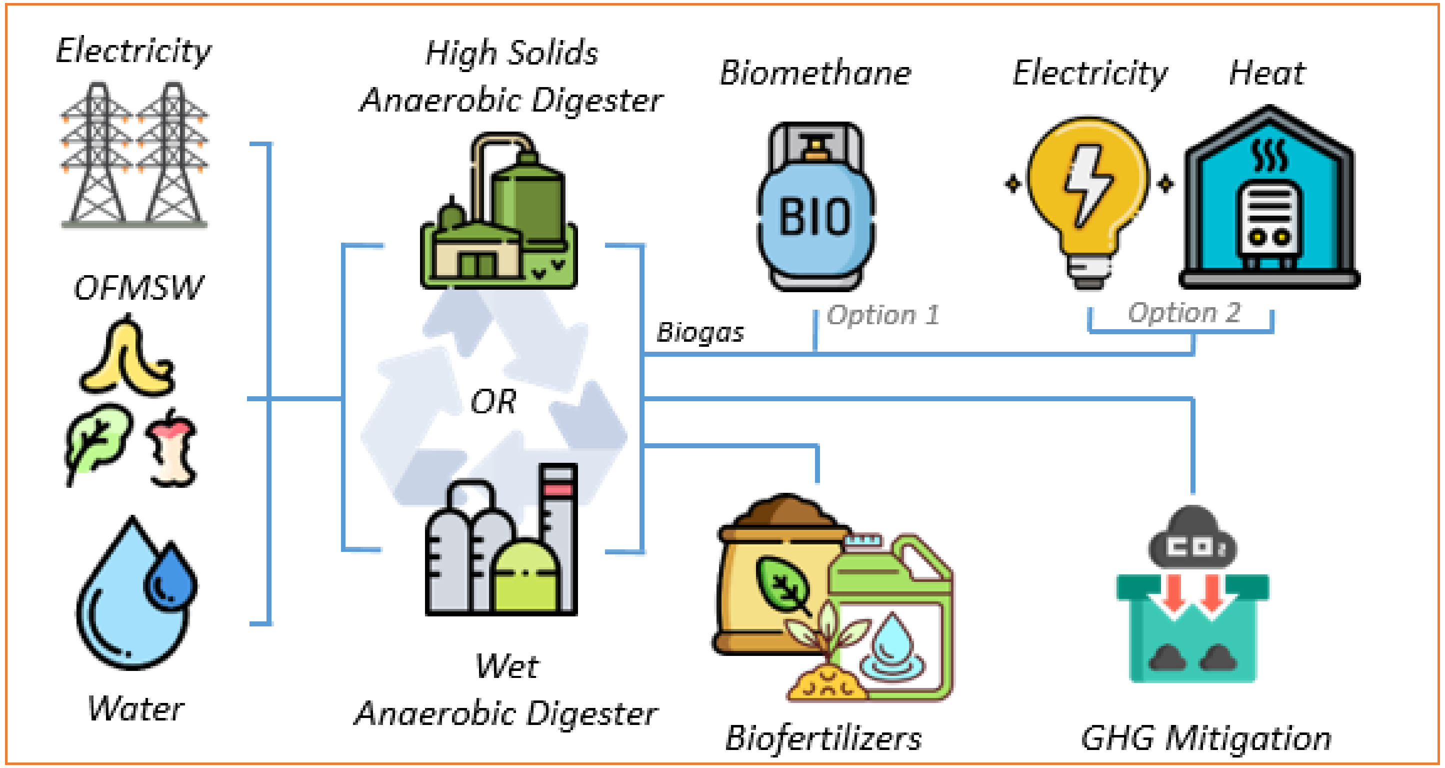
High Solids Anaerobic Digestion

- Sustainable treatment of ***organic wastes***;
- Utilization of low ***water*** quantities during its processes;
- ***Energy*** as a 2nd generation biofuels source;
- Produce considerable amounts of ***digestate*** to be used as ***fertilizer***;
- Reduce dependence on ***fossil fuels*** and ***GHG emissions***; hence, attaining Nationally Determined Contributions (NDCs);
- ***Technical simplicity***, smaller reactor volume than other technologies, and easy handling of residues;
- Generate ***socioeconomic benefits***.

Water-Energy-Food Nexus

Source: (4)

Stocks and flows compared between HSAD and WAD systems



Material Flow Analysis

Energy Balance

GHG Emissions

II. Objectives and Methods

Purpose of the research

Objective: To identify the benefits and/or disadvantages of HSAD and WAD technologies analyzing their effects on water savings, waste management, nutrient recycling, energy surplus generation, and GHG emissions mitigation.

Mean: Conduct two case studies; one HSAD treatment plant and contrast its performance with one case study of a WAD plant in Brazil;

Units of analysis: Quantities of water, waste, fertilizers, and energy resources that these treatment plants utilize and/or generate; together with the GHG emissions.

Methodology: Data Collection

Primary data Source:

- Interviews and Questionnaires
- Tools & source: Specific questionnaires to the specialists or researchers to represent resources (water, waste, fertilizers, and energy) and GHG emissions.

Secondary data Source:

- Already available data
- Tools: Documents and archives
- Data Source: Data from companies, technical reports, documents, publications, and previously collected measurements.

Life cycle inventory
(Input and output flows & stocks for each system)

Impact Categories

Mass flow and nutrient balance
Energy balance
Greenhouse gas emissions mitigation.

$$Energy\ {}^{i}/_{o}\ ratio = \frac{Energy\ Inputs}{Energy\ outputs}$$

$$CO2\ savings\ ratio\ (CO2\_SR) = \frac{\text{PEAD}\ (or\ CO2\ eq.emitted)}{\text{ESEP (or}\ CO2\ eq.saved)}$$

MFA Indicators and parameters

Inputs	*Outputs*	*Unit indicator*	*Inventory parameters*
1. Water	1. Water	Lit/day	Water
2. Organic Materials	2. fertilizers (nutrients)	Tonne/day & m^3/day	Compost, digestate and materials
3. Energy	3. Energy footprint	kWh/day	Electricity, heat
	4. GHG emissions	Kg CO_2 Eq./Tonne OFMSW	CO_2, CH_4, N_2O

Objects under investigation

AD1: Itaipu Production Unit CIBiogás: Wet digester

- Located at the Itaipu Binational complex in Foz do Iguaçú, Parana.
- Operations began in January 2017.
- The treatment plant resulted from the collaboration of Itaipu Binational and the CIBiogás Institute.
- Treats mainly organic waste from the restaurants at the Itaipu Binational area and other organic residues.

Itaipu Production Unit. Source: CIBiogás files

AD2: TMethar Comlurb treatment plant: High solids digester

- Located at the Caju neighborhood, inside the Residues Treatment Unit (UTR), in Rio de Janeiro.
- Started operations in November 2018.
- It has a processing capacity of 30 tonnes of the OFMSW.
- The treatment plant´s developers are the UFMG, in partnership with companies Methanum Tecnologia Ambiental and Comlurb.

TMethar: Bioreactors. Source: *[5]*

Itaipu Production Unit CIBiogás

Source: CIBiogás files

TMethar Comlurb treatment plant

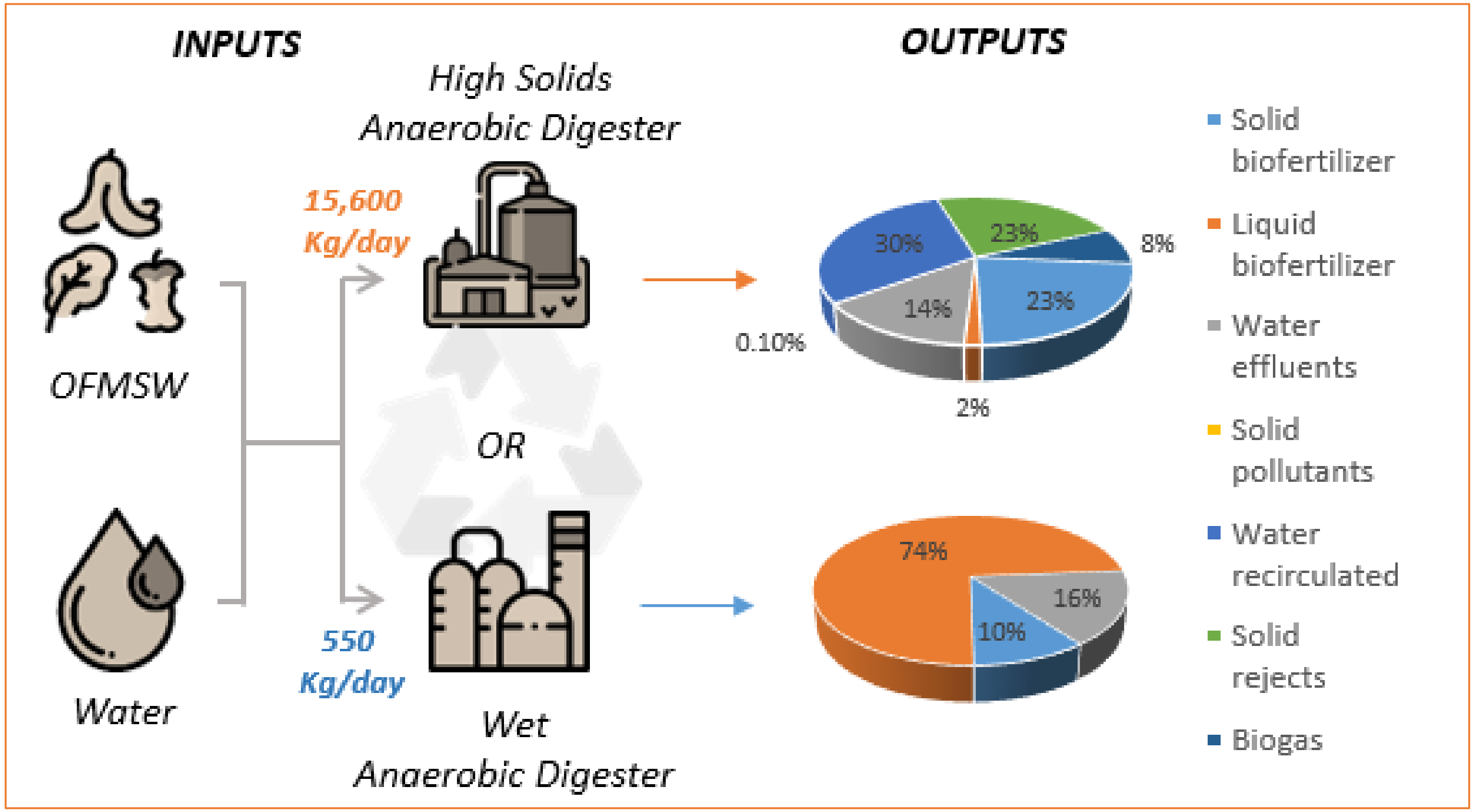
Source: [5]

Goods, substances, and energy processed throughout the treatment systems

Process	AD1: Wet fermentation		AD2: High solids fermentation	
	Operation	Goods, Substances, and energy	Operation	Goods, Substances, and energy
Disposal	Patio	Leachate	Patio	Fresh Leachate
Waste preparation and pretreatment	Pretreatment & Mixing tank	--	Percolate treatment Inoculum Production Unit (InPU)	Coarse solids & sands Effluent & fertilizer
Anaerobic digestion	Wet biodigester	Solid fertilizer Liquid fertilizers	high solids biodigester	Leachate Solid fertilizers Coarse residues
Post-processing/biogas valorization	Biogas refining Biomethane storage Alternative Option Generator CHP	Biomethane Electricity Thermal energy	Desulfurization Biogas refining Generator CHP Alternative Option Biomethane storage	Electricity Thermal energy Gaseous pollutants Biomethane

III. Results

Mass flow and nutrient balance



Mass flow and nutrient balance - Case study comparison

Water consumption	For ***AD1***, 50 liters per day of water are added to the process to reach enough fluidity. For the ***AD2*** process, no extra water is added for its treatment process.
Solid fertilizer	***AD2*** produces almost 2.5 more solid digestate or fertilizers than ***AD1***, producing roughly 233 kg/tonne OFMSW; in comparison to the 100 kg/tonne OFMSW of ***AD1***. ***AD2*** discards approximately 232 kg/tonne OFMSW of solids per day.
Liquid fertilizer	In ***AD1***, the resulting Liquid fertilizer accounts for 74% of the emitted substances (740 L/tonne OFMSW). In ***AD2***, roughly only 1.5% (14.9 L/tonne OFMSW) of the outputs are used as fertigation liquid. Approximately 142 L/tonne OFMSW are discarded.

Energy balance & GHG emissions and global warming – Case study comparison

Biogas production	Biogas production resulted in 290.91 m3 per tonne OFMSW for the ***AD1*** compared to just 55 m^3/tonne OFMSW of the ***AD2***. 5.28 times more biogas production for ***AD1***.
Energy input/output ratio	The results shows the energy efficiency of the ***AD2*** system, even though it produces less energy than ***AD1***. i.e., for the ***AD2*** from the total energy produced contained in the biogas directly, 26.4% is utilized for the internal usage; whereas for the ***AD1***, the energy consumed represents about 68% of the total energy produced.

Total project CO_2 Eq. emissions.	***AD2*** emits fewer GHG´s. 14 kg CO_2 Eq./tonne OFMSW for ***AD2*** and 201 kg CO_2 Eq./tonne OFMSW for ***AD1***, the high solids system emits only around 14.3 times less.
Overall GHG saving potential	***AD1*** can potentially save up to 3,372.5 kg CO_2 Eq./tonne OFMSW to be released, and the ***AD2*** can reach a saving potential of 683.6 kg CO_2 Eq./tonne OFMSW.
CO_2 Eq. saving ratio	For ***AD1***, 6% of the total CO_2 Eq. saved is emitted via electricity consumption and CH_4 losses. For the ***AD2***, only 2%, if biomethane was produced.

IV. Key Findings and Conclusions

Key findings and Conclusions

- Results demonstrate that the high solids system utilizes less water through its processes, as one of its main advantages.
- HSAD system produces almost 2.5 more ***solid digestate or fertilizer*** (AD1 = 100 kg/tonne OFMSW; AD2 = 233 kg/tonne OFMSW). However, WAD produces more liquid fertilizers.
- WAD system produces 5.28 times more biogas than the high solids digester.
- 26.4% of the energy contained in the biogas produced is utilized for the internal usage of the HSAD plant. Whereas for WAD, the energy consumed represents approximately 68% of the total energy produced.
- HSAD emits fewer CO2 Eq. emissions. It emits only around 7% (or 14.3 times less) of the total emitted by the WAD system. WAD system can save almost 5 times more CO2 Eq. emissions.
- The CO2 Eq. savings ratio demonstrates that currently for the WAD system, 6% of the total CO_2 Eq. saved is emitted via electricity consumption and CH4 losses. For the HSAD system, if the same conditions were presented for biomethane production, only 2% of the total CO2 Eq. potentially saved is emitted.
- Both technologies generate considerable amounts of ***solid and liquid fertilizer***, which contribute to achieving the circularity of the process, food security and sustainable agriculture.

V. References

[1] E.C. Ibtech, Digestión anaerobia para residuos sólidos, (2020) 69.
[2] Anaerobic digestion process, https://nexuspmg.com/anaerobic-digestion/
[3] The Bekon Process, https://www.bekon.eu/en/technology/
[4] The water-food-energy nexus, https://researchbriefings.files.parliament.uk/documents/POST-PN-0543/POST-PN-0543.pdf, (2016)
[5] B. Ornelas Ferreira, Estratégias operacionais para o incremento de metanização em estado sólido de resíduos orgânicos urbanos com vistas ao aproveitamento energético do biogás, (2019).



Thank you, for your cordial attention!

Rodolfo Daniel Silva Martínez, PhD