Finanziato dall'Unione europea
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Life Cycle Thinking applications of innovative circular technologies in the agricultural sector.
Life Cycle Assessment and Social Life Cycle Assessment for agricultural waste and by-products

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Spoke 8 Circular economy in agriculture through waste valorisation and recycling

Work package 8.4 Evaluation and assessment of new circular technologies in agriculture

Task 8.4.2 Multidimensional sustainability assessment of circular technologies in agriculture

CONTEST

- EU Commission promotes increased recycled waste, and by-products use to foster the development of the Circular Economy (EU Commission, 2023; EU 2019/1009).
- The agricultural waste of biomass is a valuable renewable substance (Komor and Bujanowicz-Haraś, 2020).
- Life Cycle Thinking (LCT) approach is necessary to evaluate the environmental, economic, and social implications of a product throughout its entire life and of the sustainability of the production system.

Aim: to analyse the environmental and socio-economic implications of 3 circular agriculture technologies and their innovative products:

Microbial biomass from whey for feed or agriculture purposes (Task 8.1.2 : University of Bologna)

Biochar from agricultural and forestry residues (Task 8.3.2 : CNR IBE - San Michele all' Adige and Florence)

Organic soil improver from slaughterhouse waste (Concimi Biologici srl (Cagliari))

LIFE CYCLE ASSESSMENT (LCA) AND SOCIAL LIFE CYCLE ASSESSMENT (S-LCA) METHODOLOGIES

LCA and S-LCA analysis follow the **ISO 14040-44** (2006) framework based on four steps:

1) Goal and scope; 2) Life cycle inventory analysis; 3) Life cycle impact assessment; 4) Interpretation.

LCA is a structured, complete, and internationally standardized method.
Focus: quantifies the environmental footprint of innovative products and analyse benefits deriving from their use in the agri-food supply chains.

Goal and scope: to evaluate the environmental implications of producing and using innovative products (organic soil improver, biochar, and microbial biomasses) to provide suggestions for improving supply chain management regarding environmental sustainability.

Functional unit: 1 kg of the product

System boundary: from cradle to farm gate

Inventory analysis: primary data collection based on questionnaires, interviews, and technical reports gathered in experimental sites or companies. Secondary data derived from scientific literature and accredited databases (Ecoinvent database).

Impact assessment: Environmental Footprint 3.1 method will evaluate the environmental impacts of materials and energy flows, emissions and waste streams involved in the innovative production systems.

S-LCA studies follow the UNEP 2020 Guidelines.
Focus: interactions between innovative products and the people involved in the life cycle.

Goal and scope: to evaluate the social implications of producing and using the innovative products (organic soil improver, biochar, and microbial biomasses), and to provide suggestions for improving supply chain management in terms of social sustainability.

Functional unit: 1 kg of the product.

System boundary: from cradle to farm gate

Inventory analysis: primary data collection based on farm visits, interviews, and surveys addressed to the main stakeholders (workers, suppliers, final users, local community, and society). Secondary data: PSILCA database and national reports.

Impact assessment: Type I Reference Scale Approach will be used to evaluate the social-economic impact of the circular technologies production system in terms of social performance and social risk.

CASE STUDIES

- **FastHum®** is a patent innovative technology designed by Concimi Biologici srl. This technology is based on radio frequency process for rapid non-fermentative humification and biostabilization of organic matter. The final product is a new organic fertilizer from slaughterhouse waste. This product improves soil fertility, crop quality and yield of some crops (e.g. durum wheat, tomatoes, and lettuce) in Mediterranean conditions (Mulè et al., 2020).
- **Task 8.1.2 UNIBO** technology is based on the fermentation of bovine whey and results in a value-added product (biomass) and whey with reduced Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) values. Whey serves as a growth substrate for selected and safe microorganisms, which are grown to obtain microbial biomass for use in the feed sector or as a biostimulant.
- **Task 3.3.2 IBE CNR** the pilot plant (currently TRL 6, later scaled up to TRL 7), consists of a pyrogasifier with a 1200 liter reactor and a biomass consumption rate of 50 kg per hour. Currently, pirogassification is associated with the utilization of low-grade biomass from agricultural and forestry byproducts.

EXPECTED RESULTS

This study will contribute to i) identifying process hotspots of these technologies and proposing solutions; ii) improving the environmental and social sustainability of these production systems; iii) providing data for responsible decisions and raising awareness among producers and their stakeholders.

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This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.