# Waste4Soil Project

From Food Waste to Fertile Soil: Boosting Soil Health, Strengthening Food Systems.

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# Waste4Soil Newsletter #1
# Two-Year Project
# Anniversary Edition

**Waste4Soil** is a Horizon Europe project funded by the European Commission within the framework of the **EU MISSION 'A Soil Deal for Europe'**. The Soil Mission aims to lead the transition to healthy soils via sustainable soil management. The Horizon Europe project will run for the next four years and is expected to deliver its results in 2027.

Waste4Soil aims at developing applicable recycling technical pathways to transform Food Processing Residues (FPR) into soil improvers, through a **circular, systemic, and multi-actor approach**. All food chain actors are involved at the regional level, thereby closing specific loops (nutrients, organic matter, water). All the stakeholders of the value chain have a role to play: improving management. The project envisions the development of **10 technological and methodological solutions** for recycling food processing residues from the food industry into local, bio-based circular soil improvers for improved soil health.

A **user-driven standardized Evaluation Framework** will support stakeholders from the food value chain, including waste managers, to assess their status towards food processing residues circularity and act for recycling suitable waste streams into beneficial soil improvers.

# Living Labs in Action: Showcases & Key Insights from the First Two Years

Over its first two years, **Waste4Soil** has brought together farmers, food processors, researchers, municipalities, students, and civil society in a shared effort to turn regional food-processing residues into valuable soil improvers. Across Europe, each Living Lab has become a unique demonstration of how circular solutions take shape when local actors work together. Their stories illustrate not only the technical potential of residues but also the social and institutional conditions that make innovation possible.

In **Catalonia**, the Living Lab quickly grew into a vibrant hub where producers, cooperatives, NGOs and researchers explored how **wine vinasses, pruning residues, olive pomace, brewery bagasse and pig by-products** could be transformed into safe and effective soil improvers. Through two large co-creation workshops, stakeholders compared the strengths and limitations of different valorisation routes and mapped which solutions best fit the region's Mediterranean soils and farming systems. The process showed that residues—even when abundant—require tailored processing pathways, and that involving local actors in early decision-making is essential for identifying realistic, locally adapted solutions.

In **Finland's** Päijät-Häme region, the Living Lab centred on the circular use of **fish side streams, oat husk and brewery mash**. Workshops and field visits brought aquaculture companies, municipal authorities, biogas producers and researchers into the same conversation, clarifying how these fragmented streams could be integrated into renewable energy production or soil-improver development. Several discussions revolved around regulatory challenges, especially the uncertainty surrounding fertiliser legislation, which continues to shape how quickly farmers and SMEs are willing to adopt innovative products. The Finnish experience highlighted how even small residue flows can contribute to a resilient circular economy when coordination and regulatory clarity align.

Meanwhile in **Italy**, the Emilia-Romagna Living Lab anchored its work at the Stuard experimental farm, where soil improver prototypes were introduced into ongoing crop trials. Multi-day workshops and field demonstrations allowed farmers, food industries, policymakers and soil experts to discuss performance expectations and assess real-world impacts directly in the field. The involvement of students added an educational layer that strengthened awareness of soil health challenges among younger generations. This Living Lab underscored that hands-on demonstrations are irreplaceable: trust grows when farmers see results on real crops under real conditions.

In **Slovenia**’s Istria region, workshops became a space for collaborative roadmapping, with farmers, municipalities, processing companies and researchers jointly defining their priorities and training needs. Through group work, participants shaped a shared vision for valorising **olive-oil-processing residues** and other regional by-products, stressing the importance of developing soil improvers that are affordable, environmentally friendly and easy to apply. These workshops made clear that a Living Lab is ultimately a community-building exercise, where ownership and long-term commitment grow from participatory planning.

The **Polish** Living Lab in Mazovia and Lublin built its identity around real-world infrastructure. By launching its activities at a biogas plant located next to a dairy, participants could see first-hand how **apple pomace, beet pulp, vegetable residues** and whey enter the biogas process and how digestate is managed as a soil amendment. This direct exposure to the entire waste-to-energy-to-soil cycle created a shared understanding of the technical possibilities and opened new collaborations with local industries. The experience demonstrated that innovation accelerates when stakeholders can visualise the full chain from residue to soil application.

In **Hungary**’s Transdanubia region, the focus was on strengthening governance and coordination. Committee Board workshops helped local actors clarify roles, align on priorities and integrate their work with regional policy frameworks. This Living Lab showed that effective cooperation does not happen spontaneously; it requires deliberate governance and structured decision-making, especially in regions where cross-sector collaboration is still emerging.

In **Greece**, the Greek Living Lab has focused on optimising the “double recovery” of value from food-processing residues — aiming to recover both energy (via anaerobic digestion) and nutrients/materials that can be refined into soil improvers. Workshops and stakeholder events (including the project kick-off and presentations at regional agri-events) have brought together researchers, biogas operators, food processors and local authorities to explore integrated chains that combine solid–liquid separation with selective electrodialysis for nutrient recovery. The Greek team’s approach stresses closing loops for nutrients, organic matter and water by linking biogas production with targeted downstream processing (e.g., nutrient concentration and safe formulation of soil improvers), and by engaging the whole food-value chain to address logistical and regulatory challenges.

Across all these experiences, several overarching insights have emerged. First, residues are inherently local, shaped by regional industries, landscapes and regulations—so solutions must be local too. Second, regulatory clarity is a decisive factor: where rules around fertiliser products are uncertain, innovation slows. Third, collaboration accelerates experimentation; when multiple actors meet early in the process, they can identify feasible pathways and avoid isolated trial-and-error. Fourth, demonstration builds trust: whether through experimental farms, biogas plant visits or hands-on workshops, real-world evidence remains crucial for adoption. Finally, capacity building—especially in soil biology, composting, digestate treatment and regulatory compliance—continues to be a key need across regions, highlighting the importance of engaging both practitioners and students.

**Would you like to take part in the upcoming workshop in your region? Get in touch with us at waste4soil@certh.gr.**


## Technology Pathways Powering the Waste4Soil Living Labs

Across Europe, the Waste4Soil Living Labs are demonstrating how innovative technologies can transform food-processing residues into valuable soil improvers, biostimulants and recovered nutrients. Over the first two years of the project, each region has advanced its own technological pathway—ranging from high-temperature pyrolysis to enzymatic hydrolysis and selective electrodialysis—showing that circular solutions must be tailored to local side streams and agronomic needs. Together, these technologies form a diverse and complementary portfolio that strengthens Europe's transition toward a regenerative, resource-efficient food system.

In the **Hungarian Living Lab**, technology and biology come together in the COMPO-CHAR system, an integrated pathway that starts with a state-of-the-art 3R zero-emission pyrolysis reactor. Operating at 850°C under vacuum conditions, the system converts animal by-products into a high-purity Animal Bone Char BioPhosphate, fully certified under EU REACH. This mineral-rich biochar becomes the foundation for a second transformation step: solid-state fungal fermentation using *Trichoderma harzianum*. The result is a biologically active, stable soil improver, now produced in multi-tonne quantities and applied in wheat, corn and tomato fields. The Hungarian pathway demonstrates how thermal, biological and composting technologies can be integrated to create user-ready products while meeting strict environmental and safety standards.

A very different technological route is being piloted in the **Catalan Living Lab**, where anaerobic digestion (AD) is enhanced through bioelectrochemical systems (BES). The combined AD-BES pilot helps break down pig manure, brewery residues, wine vinasses and olive pomace while electroactive bacteria boost methane production. Once digestion is complete, the liquid fraction is further treated to recover ammonium sulfate, while the solid portion supports soil-improver development. In parallel, partners are producing protein hydrolysates from porcine by-products through optimized enzymatic processes that have been scaled up to 100-liter reactors. These hydrolysates—rich in free amino acids and peptides—are currently being tested as plant biostimulants. Another activity in the Living Lab involves composting beer-production residues and grape pomace, with the resulting compost applied in vinegar cultivation. Additionally, grapevine shoots and grape stalks are being pyrolyzed to generate biochar. The Catalan Living Lab showcases how biotechnology, nutrient recovery and energy production can work together to valorize even complex organic residues.

In **Italy**, the Living Lab has established a robust enzymatic hydrolysis platform for valorizing animal- and plant-based residues—including poultry carcasses, okara and biodigester sludge. Through precise control of enzymatic reactions and multi-level scaling (from laboratory flasks to semi-industrial reactors), partners have produced a range of protein hydrolysates with distinct amino acid profiles and degrees of hydrolysis. These hydrolysates are now being tested in field conditions at the Stuard experimental farm to identify the most effective formulations for soil improvement and crop performance. Italy's approach highlights the potential of biochemical routes to create high-value soil inputs from materials that were traditionally difficult to recycle.

In the **Slovenian** Living Lab, the focus is on developing co-composts and biochar–compost blends tailored to the needs of Mediterranean soils. By incorporating olive-oil by-products and other locally available residues into controlled composting processes, the team is producing soil improvers that balance organic matter, mineral nutrients, and beneficial microbial activity. This innovation pathway highlights low-energy, easy-to-adopt processes that fit local environmental conditions and farmer expectations—demonstrating that meaningful innovation can be firmly rooted in traditional, nature-based practices. In parallel, the Slovenian Living Lab is advancing a microalgae-based route. The liquid fraction of anaerobic digestate is first pretreated by filtration through a biochar column, after which the filtered digestate serves as a nutrient medium for microalgae cultivation. A dedicated microalgae cultivation center has been established at the University of Ljubljana, equipped with open raceway ponds operating on pretreated biogas digestate. The resulting microalgae biomass is being evaluated for use as a plant biostimulant.

The **Finnish** Living Lab focuses on valorising fish side streams and other small but nutrient-rich residues characteristic of northern bioeconomies. In collaboration with regional biogas producers and aquaculture companies, the Living Lab is developing technological pathways that connect renewable energy generation with the production of high-quality soil improvers. LAB is investigating process synergies between pyrolysis and anaerobic digestion to enhance soil-improver quality. Oat husks are first pyrolyzed to produce biochar. A portion of this biochar is then introduced into the AD reactor, where it is expected not only to improve process performance but also to enhance the properties of the resulting digestate. A key research objective is to determine whether biochar addition can stabilise the AD process and mitigate ammonia inhibition when nitrogen-rich inputs—such as fish waste or fishery sludge—are used. Together, these processes show how even fragmented or seasonal biomass residues can be integrated into high-value circular systems when supported by strong regional partnerships and suitable processing technologies.

In **Poland**, the Mazovian & Lublin Living Lab uses its access to a functioning biogas plant to demonstrate how industrial-scale anaerobic digestion can underpin soil-improver production. Vegetable residues, apple pomace, whey and beet pulp are digested to produce biogas, and the resulting digestate is stabilized and explored as a nutrient-rich input for agriculture. This approach highlights the practical value of using existing infrastructure to accelerate circular strategies.

Finally, the **Greek Living Lab** leads with one of the most advanced nutrient-recovery systems in the project. Starting with digestate derived from dairy-industry residues, the process begins with centrifugation enhanced by flocculants and coagulants, enabling a clean separation between solid and liquid phases. The liquid fraction is then processed through selective electrodialysis —an current-driven membrane technology that sorts ions according to their charge and valence. This separation allows for the targeted recovery of monovalent ions through ammonia stripping to produce ammonium sulfate, while multivalent streams are recombined to precipitate struvite and hydroxyapatite, both highly valuable fertilizers. The solid fraction, rich in organic material, is evaluated for composting. This multi-step cascade illustrates how sophisticated separation technologies can unlock the full nutrient potential of digestate, transforming a challenging waste stream into multiple market-ready products.

Together, these technologies demonstrate that circularity in the agri-food sector is not a single pathway but a constellation of interlinked solutions. Whether through thermal conversion, biochemical processing, membrane separation or composting, each Living Lab adapts its technology package to the character of local residues and the needs of local farmers. As the project moves into its next phase, these technology demonstrations will continue to provide the evidence, confidence and inspiration needed for wider adoption across Europe.

# Real-World Impact: Two Years of Field Tests

The Waste4Soil project has successfully completed its first two years, marked by the full-scale deployment of **field trials** across its seven **Soil Health Living Labs**. These LLs represent crucial, real-life environments for testing how food processing residues (FPR) can be transformed into innovative, bio-based **Soil Improvers (SIs)**.

Moving beyond the initial planning phase, the Living Labs have executed extensive demonstrations with field trials focused on monitoring the SIs' impact on **soil health and plant performance**.

The **Italian** LL completed its 2024 field season by rigorously testing three innovative **Protein Hydrolysate SIs** (derived from poultry carcasses, sludge, and soybean okara) on **durum wheat** and **tomato** crops. Meanwhile, the **Hungarian** LL successfully conducted 2024 trials on **corn** and **tomato** using **ABC-COMPOCHAR** (Animal Bone bioChar), with these trials continuing into the 2025 planting season.

In **Slovenia**, a solid SI made from a combination of digestate, olive pomace, and biochar was applied to an **olive grove** in March 2025, while another set of trials involved applying a **microalgae biostimulant** to diverse crops including **maize, proso millet, winter wheat, and vineyard**. Concurrently, the **Catalonia** LL began spring applications in April 2025 to test compost/biochar and protein hydrolysate SIs on commercial **vineyards** and **olive orchards**. In the north, **Finland** successfully planted and fertilized its 2025 trials in May, focusing on **fodder barley** and integrating treatments such as digestate, fish farming sludge, and biochar. Finally, the **Polish** LL set up on-farm experiments in 2024-2025 using **plant-based compochar** on **oil seed rape, blackcurrant, and apple trees**, and **Greece** is conducting or planning field testing with compost SIs on **almond** and **durum wheat** crops for the 2025 season.

These extensive field demonstrations are generating vital data, bringing the project closer to its core mission: transforming food industry side streams into valuable resources that enhance soil fertility and support sustainable European food systems.






## Discover Our Living Labs

Learn more about the on-the-ground action in our Living Labs by watching the videos on our **YouTube channel**. Two have already been released, with more coming soon!


### Italian Living Lab

Learn more


### Finnish Living Lab

Learn more

# Waste4Soil — Publications & Research Outputs

Since its launch in 2023, Waste4Soil has built not only practical Living Labs, but also a growing portfolio of publicly accessible research outputs. The project embraces open-science principles: datasets, pilot studies, reviews and technical reports are being deposited on Zenodo (and where applicable in peer-reviewed journals), allowing practitioners, researchers and stakeholders across Europe to access, reuse and build on the knowledge.

Below are some contributions from the first two years, reflecting Waste4Soil's technological and methodological advances.

### Microalgae Production on Biogas Digestate in Sub-Alpine Region of Europe—Development of Simple Management Decision Support Tool

**What it's about:** Could microalgae thrive in the chilly sub-alpine climate? The Waste4Soil team put this to the test, growing algae in liquid digestate from local biogas plants and tracking seasonal changes. They also developed a simple decision-support tool (DST) to help operators optimize growth conditions.

**Why it matters:** This research shows that even in less-than-ideal climates, digestate can become a productive source of microalgal biomass — perfect for fertilizers, animal feed, or bioenergy. The DST makes it easy for farms to adopt this approach, paving the way for practical circular solutions.

**Click to read more here!**

### Nutrient Recovery from Digestate: Pilot Test Experiments

**What it's about:** Waste4Soil explored how to turn messy liquid digestate into a clean, nutrient-rich product. Using membranes, selective electrodialysis, and UV/ozonation, the team recovered ammonium, potassium, and phosphates while improving water quality.

**Why it matters:** This work brings us closer to transforming digestate from a waste liability into a reliable, circular fertilizer source — helping farmers, the environment, and the circular economy at the same time.

**Click to read more here!**

### Enhancing Nutrient and Water Recovery: Selective Electrodialysis vs. Conventional Methods

**What it's about:** Which method recovers nutrients and water most efficiently from liquid digestate — conventional membrane treatment or selective electrodialysis (SED)? Waste4Soil's comparative study found that SED boosted clean water recovery from ~38% to ~88%, while concentrating fertiliser-ready ions.

**Why it matters:** By highlighting smarter, more efficient digestate treatment methods, this research shows how technology can maximize resource recovery, reduce environmental impact, and support circular farming practices.

**Click to read more here!**

# Waste4Soil — Project Meetings

**Kick-Off Meeting — Thessaloniki, Greece (20–21 June 2023)**

The Waste4Soil journey officially began with a two-day kick-off meeting in Thessaloniki. Project partners — 27 organisations plus an associated partner — gathered for the first time to align overall strategy, define work packages, and plan the roadmap ahead.

The meeting laid the foundation for the establishment of seven Living Labs across Europe, each tasked with transforming food processing residues into soil improvers through collaborative, circular-economy solutions.

**6M Consortium Meeting — Terrassa, Spain (30 Nov–1 Dec 2023)**

The first milestone meeting took place in Terrassa, where partners discussed guidelines and tools to support local territories in converting Food Processing Residues (FPR) into Soil Improvers (SI).

This meeting kick-started the co-creation and co-implementation activities in the Living Labs — engaging stakeholders including food industries, waste managers, fertilizer producers, farms and citizens — and set the stage for demonstration of "ready-for-practice" circular solutions.

**18M Consortium Meeting — Kajaszo, Hungary (16–17 Oct 2024)**

Approximately a year and a half after the kick-off, partners gathered at the Biofarm in Kajaszo for a hybrid two-day meeting. The agenda included presentations on progress, updates from the seven Living Labs, discussions on soil-health, FPR valorisation strategies and logistic optimisation for nutrient recovery chains. The second day featured a tour of the Biofarm facilities and an interactive "peer-lead coaching" session — a great opportunity for hands-on exchange of experiences and problem-solving across labs.

**24M Consortium Meeting — Lahti, Finland (3–5 June 2025)**

The most recent major gathering brought together all Waste4Soil partners at the campus of LAB University of Applied Sciences in Lahti.

Over three days, the consortium reviewed two years of work, shared updates from all work packages, and planned the next phases. The meeting also featured visits to Finnish Living Lab sites — showcasing concrete applications of circular bioeconomy innovations.

This milestone reaffirmed the consortium's commitment to advancing soil health across Europe through collaborative, sustainable solutions.

## Social media

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Waste4Soil Newsletter

Our mailing address is:
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