FERTITEC

INNOVATIVE RECOVERY TECHNIQUES FOR ALTERNATIVE FERTILISERS

FERTITEC: Circular Solutions for Livestock Waste Valorization

Evidence-Based Technologies for Nutrient Recovery and GHG Reduction in Animal Production

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PARTNERS

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The Livestock Waste Challenge

Scale of the Problem

- 30 million tons of manure produced annually (Sweden)
- Contains 100,000 tons N and 20,000 tons P
- Only ~3% currently processed through anaerobic digestion
- 174,000 tons mineral N fertilizer still imported

Environmental Impacts

- 48,500 tons N lost via leaching
- 39,500 tons NH_3 emissions
- 6,000 tons N_2O emissions
- Contributing to Baltic Sea eutrophication

We have an abundance of nutrients in waste while simultaneously importing fossil-intensive fertilizers

FERTITEC: A Comprehensive Technology Database

Project Scope

- EU Horizon CSA Project (Grant 101181513)
- 184 Technologies, Techniques & Practices mapped
- Covers EU and African Union regions
- Integration of 18 prior EU projects (NOVAFERT, SUSFERT, NUTRIMAN, etc.)

Primary Resource Streams

- **Agricultural biomasses (>50%):** Livestock manure, slurry, digestate, crop residues
- **Urban wastewater:** Sewage sludge, 212,000 tons/year dry matter
- **Municipal biowaste:** Food waste, green waste
- **Industrial side-streams:** Food processing, wood industry by-products
- **Blue biomasses:** Fish/shellfish by-products, seaweed, aquaculture waste

Summary Table: Overview of Common Technologies and Their Features

Technology/Technique	Typical Raw Materials	Fertiliser Product Type	Strengths	Challenges
Anaerobic Digestion (AD)	Manure, agricultural residues, biowaste	Digestate (liquid/solid fractions)	Energy co-production, nutrient-rich fertiliser	High investment, transport/logistics, regulatory issues
Composting	Manure, municipal organic waste, crop residues	Compost, soil improvers	Mature, low-cost, improves soil structure	Requires space, potential contaminants
Thermal Treatments (Pyrolysis, Incineration, HTC)	Sewage sludge, biomass, manure	Biochar, mineral concentrates	Pathogen destruction, carbon sequestration	Energy-intensive, emission control
Chemical Nutrient Recovery (Struvite, Ammonium Sulphate)	Wastewater, digestate	Inorganic mineral fertilisers	High nutrient concentration, market-ready products	Regulatory acceptance, cost
Separation Technologies (Membrane, Centrifugation)	Digestate, slurry	Concentrated fertiliser fractions	Improves nutrient concentration and product quality	Technology cost, operational complexity
Bio-Based Innovations (Microalgae, Insect Frass, Hydrolysates)	Food industry waste, aquaculture residues	Biostimulants, organic fertilisers	High value, supports sustainable practices	Market acceptance, regulatory clarity

Technology Readiness: Most Solutions Are Market-Ready

TRL Distribution

- **TRL 8-9 (Operational):** ~65% of technologies
- **TRL 6-7 (Demonstration):** ~15%
- **TRL 3-5 (Development):** ~20%

Key insight: Two-thirds of mapped technologies are fully qualified and proven in operational environments - ready for immediate deployment.

Most Mature Technologies

- **Anaerobic Digestion:** TRL 9, widely implemented
- **Composting:** TRL 9, established practice
- **Chemical Nutrient Recovery:** TRL 8-9 (struvite, ammonium sulfate)
- **Thermal Treatments:** TRL 8 (pyrolysis, biochar production)
- **Separation Technologies:** TRL 8-9 (membrane filtration, centrifugation)

Anaerobic Digestion: The Cornerstone Technology

Process & Products

- Anaerobic bacterial digestion of manure and organic waste
- **Biogas output:** CH_4 + CO_2 for energy
- **Digestate output:** Nutrient-rich fertilizer
- Can process 30M tons manure + co-substrates

Swedish Case Study

- Current: ~2 TWh biogas/year
- Potential: ~7 TWh/year from stall manure alone
- Only 3% of manure currently processed

Multiple Benefits

- **Energy:** Replaces fossil fuels in transport and heat
- **Fertilizer:** Digestate retains N, P, K nutrients
- **GHG Reduction:** Captures methane, reduces N_2O
- **Odor:** Significantly reduced vs. raw manure
- **Pathogens:** Destroyed during digestion
- **Economics:** Energy revenue + fertilizer savings

Untapped potential: 5 TWh/year additional biogas from livestock manure = 250,000 tons CO_2-equivalent reduction

Chemical Nutrient Recovery: High-Purity Fertilizer Products

Technology	Source Material	Product	Key Advantages
Struvite Precipitation	Digestate, wastewater	$MgNH_4PO_4$ crystals	High P concentration, slow-release, market-ready
Ammonium Sulfate Recovery	Livestock slurry	$(NH_4)_2SO_4$	Concentrated N, prevents ammonia emissions
Membrane Filtration	Digestate liquid fraction	Concentrated nutrient solution	Transportable, standardized composition
Ammonia Stripping/ Scrubbing	Manure, digestate	Ammonium nitrate/sulfate	Removes N from waste, creates marketable product

Market Context

- EU imports 11,500 tons P fertilizer annually (finite resource)
- Urban sewage contains 2,000 tons P/year potentially recoverable
- Struvite selling at competitive prices to conventional P fertilizers
- EU Fertilising Products Regulation (2019/1009) enables market access

Implementation Results: Swedish Case Study

Energy & Emissions

Baseline (Current)

- Direct energy: 4-5 TWh/year
- Fossil fuels: 2.3 TWh/year
- Biogas production: 2 TWh/year
- NH_3 emissions: 39,500 tons
- N_2O emissions: 6,000 tons

Potential with Full Implementation

- Biogas: 7 TWh/year (+250%)
- Fossil fuel replacement: 100% of diesel
- NH_3 reduction: 50-70%
- N_2O reduction: 40-60%

Nutrient Cycling

Current Situation

- 174,000 tons N imported as mineral fertilizer
- 11,500 tons P imported
- Only 3,000 tons N recycled from sewage
- 37 kg N/ha surplus on farmland

Circular Economy Target

- 30-50% reduction in mineral fertilizer imports
- Urban sewage: 7,000 tons N, 2,000 tons P recoverable
- Manure nutrients: 100,000 tons N, 20,000 tons P optimized
- Nutrient surplus reduced to <25 kg N/ha

Implementation Barriers & Solutions

Barrier Type	Specific Challenges	FERTITEC-Identified Solutions
Regulatory	Fragmented national regulations; sewage sludge restrictions; lengthy permitting; REACH costs	Harmonize EU framework; update regulations for safety-certified products; streamline approval processes
Economic	High upfront investment; competition with cheap mineral fertilizers; logistics costs	Policy incentives; carbon pricing; green loans; subsidies for circular technologies; local processing to reduce transport
Technical	Variable raw material composition; inconsistent product quality; lack of real-time nutrient measurement	Standardization protocols; quality certification; precision application technologies; digital platforms for quality tracking
Social	Limited farmer trust; lack of information; concerns about contamination; insufficient stakeholder engagement	Demonstration projects; farmer education; transparent certification; third-party testing; co-development with end-users
Market	Insufficient demand signals; dominance of conventional fertilizer industry in policy-making	Public procurement preferences; mandatory recycling targets; balanced stakeholder representation; consumer awareness campaigns

Pathway Forward: From Technology to Transformation

Near-Term Actions (2025-2027)

- **Scale proven technologies:** AD, composting, struvite recovery (TRL 8-9)
- **Establish demonstration facilities** in key livestock regions
- **Develop quality standards** and certification schemes
- **Launch farmer education programs** and knowledge exchange platforms
- **Harmonize regulations** across EU member states

Medium-Term Development (2027-2030)

- **Deploy precision application technologies** for organic fertilizers
- **Establish urban-rural nutrient loops** recovering wastewater nutrients
- **Scale biogas production** to meet transport sector needs
- **Implement carbon pricing** reflecting true environmental costs
- **Create green financing mechanisms** for circular infrastructure

Long-Term Vision (2030+)

- **Achieve 30-50% mineral fertilizer substitution**
- **Close nutrient loops** between cities and farms
- **Carbon-neutral livestock production** through energy circularity
- **Restore nutrient balance** in sensitive ecosystems

Key Conclusions

Livestock waste is not a problem to dispose of — it is a valuable resource to harness

Core Messages

1. **Technology is ready:** 65% of FERTITEC technologies are TRL 8-9, proven and operational. The question is deployment, not development.
2. **Multiple benefits:** Circular nutrient management delivers energy security, GHG reduction, water quality protection, and economic returns simultaneously.
3. **Massive untapped potential:** From Swedish data alone, 5 TWh biogas and 50-70% emissions reductions are achievable with existing waste streams.
4. **Barriers are solvable:** Regulatory harmonization, economic incentives, quality standards, and farmer engagement address the main obstacles.
5. **Systems transformation required:** Success requires coordination across agriculture, energy, urban planning, and environmental policy sectors.

FERTITEC Contribution

The FERTITEC database of 184 technologies provides the comprehensive toolbox for circular nutrient management. Combined with real-world evidence from Swedish and EU-wide implementations, we now have a clear roadmap from livestock waste problem to circular resource economy.

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Open Access at FERTITEC: https://doi.org/10.5281/zenodo.15790135

Resources & Further Information

- **FERTITEC Project:** EU Horizon CSA (Grant Agreement 101181513)
- **FERTITEC Database:** 184 technologies publicly available via Zenodo repository
- **Swedish Circular Agriculture Study:** "The Road to a Circular Economy in Swedish Agriculture" (RISE, 2020)
- **Conference Theme:** V - Pollution and Carbon Reduction, and Utilization of Livestock Waste

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Thank you! Tack! 谢谢!

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