



NUTRI • KNOW

# Application

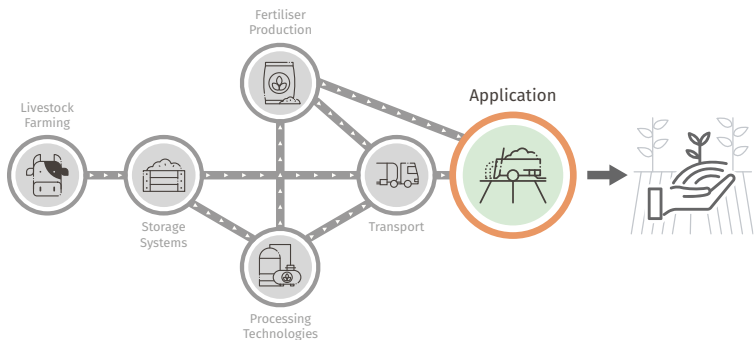
Technologies, tools and recommended practices  
from NUTRI-KNOW's EIP-AGRI Operational Groups





# Introduction

Nutrient Management is one of the most important areas of interest for farmers in several countries in Europe. Along the nutrient management value chain, sustainable and efficient application is a crucial step to optimise nutrient use efficiency while minimising the environmental impact. This booklet discusses state-of-the-art nutrient application in agricultural systems, followed by an overview of the innovative technologies, tools and recommendations for improved application practices. It highlights the key outcomes derived from the EIP-AGRI Operational Groups engaged in the NUTRI-KNOW project, including the use of technologies and fertilising products such as struvite and ammonium salts recovery from manure, on-site tools such as slurry concentrator and conductometer, as well as recommended practices integrating soil, fertiliser and water management. Furthermore, the booklet explores the benefits and current status of these technologies, tools and recommended practices in the representative regions, supporting the decision-making process of farmers and practitioners.



# Application

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In response to the challenges of increasing fertiliser cost but low nutrient use efficiency in traditional application practices, 7 of the 12 engaged operational groups in the NUTRI-KNOW project demonstrated different approaches for improved nutrient application strategies. This section summarises the key outcomes, including two technologies for the recovery of struvite and ammonium salts from manure/digestate and the application of the derived products, two innovative tools (i.e. slurry concentrator, conductometer) to support fertilisation decisions, and three recommendation schemes integrating soil, crop, fertiliser, and water managements. The involved activities, results and the current status are discussed to provide practical guidance for future implementation by end-users crossing Europe.



## Organic Farming and Nutrient Management

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Nutrient management on organic farms is based on working with ecological processes as well as the recycling of existing nutrients to build soil fertility, including soil organic matter and biological activity that promotes circular systems and help to minimise dependence on external inputs. Alongside good soil management, efficient use of nutrients is critical owing to their limited availability. Additional sources of organic materials outside the farm may be needed to secure sufficient nutrient levels, particularly on stockless farms, where links between arable and livestock enterprises may not be established. Under EU organic legislation application of organic manures and other waste materials must be authorised for use in organic production.





# Struvite Precipitation to Reduce Ammonia Emissions From Digestate Application

Application of manure and digestate derivatives releases less ammonia ( $\text{NH}_3$ ) and greenhouse gas (GHG) emissions than raw materials. The Operational Group Struvite developed and implemented a prototype for a farm-scale system to recover nitrogen and phosphorus from digestate in a small volume of stable matrix, with a reduced nutrient and organic matter content in the remaining fraction. The recovered nitrogen forms a slow-release renewable recovery fertiliser (Struvite) which can replace synthetic fertilisers in areas characterized by nutrient deficiencies due to a reduced livestock presence.



Pilot treatment plant for struvite precipitation from digestate

## Struvite Precipitation to Reduce Ammonia Emissions From Digestate Application



On-site measurement of ammonia emissions by Wind tunnel technique (left) and GHG emissions by static Chamber (right)

### Benefits:

- Due to depleted content of N, soil application of the treated digestate led to a 19% reduction in the N emissions (counted as sum of N-ammonia and N-nitrous oxide) as compared to the untreated digestate.
- Thanks to the saline and stable forms of nitrogen and phosphorus, application of the precipitated struvite resulted in a 63% of N emissions reduction as compared to the untreated digestate.
- The circular management of pig manure and transformation into Struvite shifts the problem of climate-altering gas emissions from the manure into a resource.



### Current Status:

Building on these findings, research and activities will continue in a newly funded Struvite project. The precipitate containing struvite will be further refined/evaluated to effectively replace the phosphate minerals in accordance with the EU fertilising product regulation.



More information can be accessed at the home page of the Operational Group **STRUVITE**

# Applying Recovered Ammonium Nitrate as Alternative Fertiliser

The Flemish agricultural sector faces a paradoxical scenario of nutrient demand in the form of fertilisers despite nutrient surplus from manure. In 2020, the European Commission proposed the “RENURE” criteria to allow the safe use of recovered nitrogen from manure to replace chemical fertilisers. Ammonium salts (ammonium sulphate or nitrate) recovered from manure through a stripping and scrubbing process show the potential to be used as a priority RENURE product. The agronomic performance of the recovered ammonium nitrate was evaluated in five field trials set up in 2022 and one in 2023.



Ammonium nitrate recovered from manure stripping and scrubbing process



## Applying Recovered Ammonium Nitrate as Alternative Fertiliser

### Benefits:

- The ammonium nitrate recovered from manure showed comparable effectiveness and fertilising value as artificial fertilisers.
- Applying ammonium nitrate with a row tiller or with injection is preferred as a low-emission method over using a spray boom.
- A more realistic alternative is to apply it with a spray machine under the right conditions and immediately working it into the soil.



Application of ammonium salts to grass and vegetable crops through injection to reduce ammonia emissions



### Current Status:

The lower nitrogen content in the recovered ammonium nitrate than the artificial fertiliser is one main bottleneck in practice, requiring a larger application volume that the fertiliser machine has to be replenished more often, as the storage is located far from the application plot. In addition, the status of animal manure in the current regulations is limited for ammonium nitrate application.



More information can be accessed at the home page of the Operational Group **RENURE**

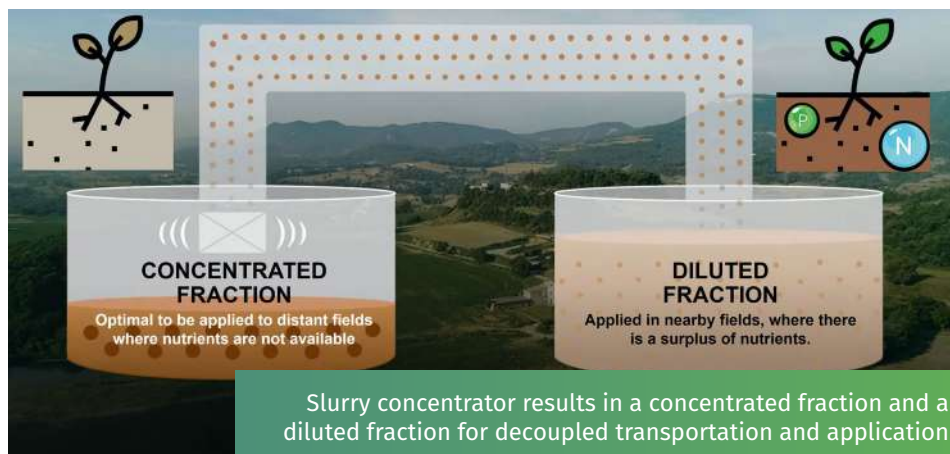
## Slurry Concentrator for Enhanced Soil and Fertiliser Management

Conventional manure separation results in a liquid and a solid fraction, each requiring different application machinery, which increase the complexity of application. The innovative slurry concentrator yields two liquid fractions: one with concentrated organic matter and nutrients to be transported and applied to distant fields where nutrients are not available; and the other with a low nutrient concentration to be applied in nearby fields.



The innovative slurry concentrator separates manure into two liquid fractions, which are stored in dedicated ponds for optimised nutrient application

## Slurry Concentrator for Enhanced Soil and Fertiliser Management



### Benefits:

- Using the same equipment for both fractions derived from the slurry concentrator reduces both investment and operating costs and the time required for management.
- The system enables easier monitoring of the applied nutrients through online devices capable to facilitate precision fertilisation, minimise nutrient losses and reduce emissions, thereby optimising soil health and productivity.
- The proposed new separator is a mobile device that can be shared with a group of farmers or a cooperative on different farms.
- The device is designed for low maintenance and energy consumption, with minimal electricity usage. Additionally, it requires no building work and has very low installation costs, making it easy to set up.



### Current Status

The Cooperative Plana de Vic offers a free simulation of the viability of the slurry concentrator on your farm.



More information can be accessed at the home page of the Operational Group **Slurry Concentrator**

# Manure Management Tools for Optimised Fertilisation Plan

Within the Operational Group Manure Management Tools, innovative tools including conductivity meters, precision machinery, and computer applications have been validated for the optimisation of livestock manure management and agricultural fertilisation, from both an economic and environmental perspective. Slurry was applied before sowing using a fan equipment to bury the slurry at a depth of 0-30cm, and when crops were less than 10cm in height, using hoses. Farmers received advice and training for crop variety options, pest control, climate, bottom and cover fertiliser applications, etc.



Application of slurry before sowing

## Benefits

- The employment of a conductivity meter enables in-situ and real-time monitoring of the nutrient content that is applied to the crop.
- The online monitoring devices installed in transport tanks record information including the location and routes of the application vehicle,



## Manure Management Tools for Optimised Fertilisation Plan

timetables, number of operations per loading and unloading point, the total kilometres travelled, etc., making it possible to generate fertilisation plans more quickly and accurately.

- The use of hose equipment to apply liquid manure during crop growth brings the supply of nutrients closer to the moment of maximum nutrient uptake by the crops and improves the efficiency of the nutrients applied.



Application of slurry when crop is growing



### Current Status

Several transversal actions and pilot experiences have been carried out, and the management tools are near-to-practice.



More information can be accessed at the home page of the Operational Group **Manure Management Tools**

# Sustainable Farming Techniques to Apply Renewable Fertilisers

SOS\_AQUAE developed an innovative system to increase the use of the liquid fraction of digestate by mixing it with water in fertigation, offering an interesting option in regions where crops require water.

Three innovative agrosystems stand out compared to traditional practices looking at soil management, chemical fertiliser input, conventional application and sprinkler irrigation. This includes:

- Non-tillage based on spring-summer crops (sorgum and maize) alternating with autumn-winter cover crops, fertigated with ammonium sulphate from stripping treatment of digestate, injected through drip lines in sub-irrigation.
- Minimal tillage based on double crops, the first for food and the other for biogas, fertigated with microfiltered digestate injected through drip lines in sub-irrigation.
- Conventional production methods for food and non-food but fertigated with microfiltered digestate spread through a rainger irrigator.



Fertigation with microfiltered digestate from slurry tank

### Benefits

- Thanks to minimum tillage, the sub-irrigation drip lines have a multi-year duration.
- Distributing the nutrients mixed with the irrigation water on growing crops reduces nitrogen leaching and ammonia emissions to almost zero.
- The efficient distribution of water in sub-irrigation avoids water saturation of the soil and the emission of nitrous oxide.
- These innovative techniques for applying digestate extend its spreading periods and avoid soil compaction due to the passage of the slurry tanker.
- The sub fertigation avoids ammonia and odor emissions compared to conventional digestate application.



### Current Status

The digestate microfiltered injected in sub fertigation drip-lines technology is now on the market. There is also a follow-up project with the development of a demonstration case in the Italian region of Sicily.



More information can be accessed at the home page of the Operational Group **SOS\_AQUAE**

# Sustainably Restoring, Protecting and Enhancing Water Quality

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Elevated bacteria levels of bathing water quality at Duncannon beach, Wexford, together with the loss of its 'Blue Flag' status of environmental excellence in 2007 had a major impact on the tourism potential of the area. As a result, 35 farmers from 4 dairy, 8 tillage and 23 dry stock farms, covering a catchment area over 975 hectares, came together to contribute to the recovery and long-term retention of the Blue Flag status at Duncannon beach. With the guidance of a dedicated sustainability manager, farmers developed a results-based reward scheme to assess the pollution risks on the farms and develop Pollution Potential Zone (PPZ) maps using a traffic light system.

The overall farm PPZ status ranged from:

- “Red” poorly managed – posing a moderate/ high risk
- “Yellow” well managed – but still posing a low risk
- “Green” very well managed - no/ minimal risk

Improvement in PPZ scores requires water protection and enhancement works on farms and the catchment area including:

- Fencing off 15.5km of watercourses.
- Moving water troughs 20m from waterways.
- Conducting soil sampling and developing nutrient management plans for all farms.
- Placing sediment traps on farms to trap and filter run-off.
- Improving farm roadways.



## Sustainably Restoring, Protecting and Enhancing Water Quality

- Encouraging native riparian zones and planting native hedgerows.
- Sowing winter cover crops.
- The participating farmers also received advice on lime applications, soil nutrient assessment, hedgerows, native woodland planting and water quality.

### Benefits

- At a farm level, catchment farms became more efficient, the number of septic tank failures reduced and compliance above the Nitrates Directives was observed.
- At a local level, a reduction in bacterial pollution at Duncannon beach was recorded and there was an improvement in ecological quality.
- At a community level, the participants reported a sense of ownership, responsibility and appreciation for the local water environment.



Sediment trap established on a local farm in Wexford



Fencing on Irish farms



### Current Status

This cooperation project provides pilot-based evidence that the methodologies developed for results-based land payments in protecting water courses and biodiversity are transferable and can protect other resources such as water quality and rural tourism.



More information can be accessed at the home page of the Operational Group **Duncannon Blue Flag Farming & Communities Scheme**

# Improving Soil and Nutrient Management on Organic Horticulture Farms

The Irish Organic Association worked with 11 Irish organic horticulture growers nationwide to optimise production methods and improve the continuity of short supply chains through grower collaboration. As part of the project, a multi-annual investigation of the effects of short-term green manures on summer and winter cash crops in organic vegetable production was conducted (July 2018 - May 2021). Over 3 years, different summer and winter green manure mixes were sown and grown for 2 and 6 months respectively alongside control plots. The green manures were incorporated into the soil, followed by the establishment of specific cash crops.



Green manure trial site in Ireland

## Benefits

- Green manure application before cash crops over the three years achieved overall beneficial effects, including better weed control, more beneficial insects, more and greater functional diversity of soil bacteria, greater soil organic matter content and earlier developing crops compared to control plots

## Improving Soil and Nutrient Management on Organic Horticulture Farms

- Low-growing green manures e.g., clover, ryegrass support more beneficial insects, while high-biomass green manures e.g., cereals, phacelia, and buckwheat help to increase soil organic matter.
- Integration of green manure mixes into rotations accelerated the growth of all four cash crops and thus demonstrated the potential for growers to extend the growing period for crops under Irish conditions.



The MOPS Growers Report provides an overview of the green trials results

Table: Green Manure Trial Mixes and Cash Crops

	Summer	Winter
<b>Green manure mixes</b>	<ol style="list-style-type: none"><li>1. Buckwheat/phacelia</li><li>2. Rye/phacelia</li><li>3. Persian/Egyptian clovers/Annual ryegrass</li></ol>	<ol style="list-style-type: none"><li>4. Vetch/Crimson clover/Annual ryegrass</li><li>5. Rye/vetch</li><li>6. Squarrose clover/Crimson clover/Vetch/Japanese oats/Wild rye</li></ol>
<b>Cash crops</b>	<ol style="list-style-type: none"><li>7. Brown onion</li><li>8. Pointed cabbage</li></ol>	<ol style="list-style-type: none"><li>9. Broccoli</li><li>10. Red oak lettuce</li></ol>



### Current Status

A MOPS Growers Report is available as a reference for organic growers already operating in the sector and potential new entrants.



More information can be accessed at the home page of the Operational Group **MOPS**



## Summary

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### Technologies to **Develop Novel Products** With **Higher Nutrient Efficiency** and **Lower Environmental Impact**

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- Struvite precipitation from digestate significantly reduces ammonia and greenhouse gas emissions after the fraction has been treated prior to application.
- Ammonium salts recovery from stripping and scrubbing of manure or digestate show high potential as chemical fertiliser substitutes.

### Tools to **Optimise the Fertilisation Plan** and **Reduce Cost**

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- The innovative slurry concentrator produces two liquid fractions for use as fertilisers, reducing operational costs and enabling precision fertilisation for improved soil health and productivity.



## Recommendations for Integrated Soil, Crop, Fertiliser and Water Managements

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- Innovative agrosystems integrating minimal tillage, fertigation with derivatives from the liquid fraction of digestate, and injection through drip lines in sub-irrigation.
- A simple, cost-effective management plan for water protection improvement, equipped with the Pollution Potential Zone (PPZ) maps.
- Short-term (2-6 months) incorporation of green manure to support the development of summer and winter cash crops in organic vegetable production.

## Outlook

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- Struvite and ammonium salts recovered from manure as alternative fertilisers can reduce the fertiliser cost and minimise the environmental impact.
- On-site tools for nutrient monitoring and implementing support precision fertilisation strategies can reduce costs and time, increase nutrient use efficiency and productivity.
- Fertiliser application involves the integration of soil, crop, fertiliser and water management practices.





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