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Poultry Manure: a study into storage, bi-product capabilities & the impact on the environment

Written by:

David Throup NSch

October 2025

A NUFFIELD FARMING SCHOLARSHIPS REPORT

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"Leading positive change in agriculture. Inspiring passion and potential in people."

Date of report: March 2025

Title	Poultry Manure: a study into the storage, bi-product capabilities & the impact on the environment.
Scholar	David Throup
Sponsor	BEMB TRUST
Objectives of Study Tour	To find examples of how other countries deal with the product of poultry manure. Understand how other countries manage poultry manure as a product. Understand the bi-product options of poultry manure.
Countries Visited	UK, Gran Canaria, Austria, Slovenia, New Zealand, Netherlands.
Messages	New legislation is coming and farmers will have to find solutions to adapt to this. There are opportunities to solve the problem and add value One solution may not suit others. Investment will be needed to solve this problem.

EXECUTIVE SUMMARY

The growth of poultry production within the agricultural sector has led to large amounts of manure being produced. This report focuses on the best methods to dispose of the product while minimising its environmental impact.

Environmental regulations on water and air quality are increasing, prompting innovation to find solutions. Legislation now mandates best practices, such as specific periods for spreading manure and reduced application rates, as well as the location of heaps.

This study explored ways to safely use poultry manure, aligning with environmental requirements and business sustainability. The goal was to utilise poultry manure as a by-product and develop industry-suited methods. Poultry manure is valuable as a nutrient-rich organic fertiliser and as a fuel source for energy production.

Proven concepts are increasingly being adopted for example the use of manure to produce energy, either through a litter burner or an anaerobic digester. Additionally, new technologies are being developed that could provide further opportunities, such as small-scale anaerobic digestion plants with nutrient stripping technology and composters that use a bio catalyst to accelerate the composting process.

My study explored alternative ways to handle and process poultry manure, aiming to add value and reduce manure heaps that contaminate water and soil.

I visited countries where I had identified possible solutions and novel ideas. These ranged from drying, pelleting, composting and litter burning and anaerobic digestion. These methods all require different levels of investment as well as rewards. Many of these technologies can carry a large capital investment which may be uneconomical for a small-scale producer, so I wanted to find a scalable solution.

Handling poultry manure presents various challenges and opportunities, with different businesses requiring unique solutions. No single technology fits all producers, as skillset needs can vary. My report aims to find a beneficial solution for the poultry industry, both for my own business and to share my findings.

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DISCLAIMER

The opinions expressed in this report are those of the author alone and not necessarily those of the Nuffield Farming Scholarships Trust, of the author's sponsor, or of any other sponsoring body.

Please note that the content of this report is up to date and believed to be correct as at the date shown on the front cover.

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CHAPTER 1: INTRODUCTION

I live with my wife Emma and am a partner in the family farming business. I farm with my father, uncle, brother and cousins. The farm is situated near York, North Yorkshire. The business consists of three main enterprises: poultry, dairy and arable. In addition, we also have rental units and utilise renewables (solar, hydro and biomass) across the three enterprises.

I have grown up in our farming business and worked across the enterprises. I have now taken a leading role on the poultry side of the business and look to drive the business forward.

My responsibilities include the day-to-day management of three free range poultry layer units, each housing 26,000 birds, and the day-to-day management of a rearing unit where we rear our own birds from day old chicks. We also have our own mill and produce up to 70 per cent of our chicken feed from the arable enterprise of the business. This adds value to the arable crops, as well as reducing our environmental impact to a minimum with reduced road haulage and circular farm practices.

I have always been practically minded and have a keen interest in engineering, I've achieved qualifications at Askham Bryan College and at Harper Adams University. These courses have aided my ability to problem-solve throughout my farming career.

Away from the business of farming, I generally have some project in progress, including home renovation and working on my Land Rover. I have found that farming has offered me opportunities to travel and meet new and interesting people starting from my days with the Young Farmers Clubs and agricultural colleges and later becoming a participant in the National Farmers Union's Poultry Industry Programme, which all led me to apply for a Nuffield Farming Scholarship.

CHAPTER 2: BACKGROUND TO MY STUDY SUBJECT

Having worked across poultry and arable for over 25 years and, as our poultry enterprise has grown, the volume of poultry manure has also increased. Our poultry enterprise consists of modern multi-tier systems in the laying sheds. These have conveyors to remove the manure from the sheds and generally run twice a week. This is great for the chickens as it removes any ammonia build up and heavily reduces flies. Problems then arise as the manure is tipped in fields all year round until the time it can be used as a crude organic fertiliser. The manure, as it weathers, will leach or run-off into the ground reducing the ability for anything to grow in that area of land for the next few years. This challenge is faced across the majority of the poultry industry.

There are also other pressures, from increasing legislation as there is growing water pollution attributed to the poultry industry; Appendix D describes England's nitrate vulnerable zone requirements.

Figure 1. Layer manure field heap left open over winter.
Source: Author's own

The challenge facing the industry is how to deal with the vast quantity of raw manure to prevent environmental issues like reduced ground-growing capacity and water pollution. Practical solutions are needed to utilize manure as a valuable nutrient source and fertilizer, enhancing farm sustainability; see Appendix A Manure & Soil Biodiversity in Europe.

Across the industry, there is a belief that there is a better solution to this problem. Through journals and word of mouth, there are solutions out there each requiring different levels of investment. I wanted to explore some of these ideas and find the gold standard for my industry and investigate what options are available.

CHAPTER 3: MY STUDY TOUR

For my study I wanted to explore what technology was available and the incentive for its application.

My topic was based on poultry manure, its use as a bi-product and storage. The issues presented by legislation and adding value were my key interest, so the UK and Europe were going to be the main destinations.

I also wanted to get a comparison with other countries with possibly more up and coming industries and investigate their approach to dealing with manure.

Avian Influenza (Bird Flu) did manage to cut short some of my planned visits within the poultry industry because of increased biosecurity measures at home and across Europe.

Where	**When**	**Comments**
Gran Canaria	November 2022	Composting in 24hrs
Austria / Slovenia	December 2022	Pelleting Manure
New Zealand	March 2023	New relatively small industry. Triennial Conference
Netherlands	May 2023	Ad Plant, Manure drying
United Kingdom	March 2022-June2023	Contemporary Scholars Conference, Various meetings and visits

CHAPTER 4: CHALLENGES ASSOCIATED WITH POULTRY MANURE

The challenge of managing poultry manure effectively is to utilise its valuable nutrients to enhance farm success (section 4.1) while preventing environmental harm (section 4.2).

4.1 Nutrient values

A typical poultry manure nutrient guide is shown in Figure 2. The figures are taken from the Agriculture and Horticulture Development Board nutrient management guide (RB209). This shows that as the dry matter is increased, the nutrient values are higher.

Dry matter %	Total nitrogen (kg N/t)	Total phosphate (kg P2O5/t)	Total potash (kg K2O/t)	Total sulphur (kg SO3/t)	Total magnesium (kg MgO/t)
20	9.4	8.0	8.5	3.0	2.7
40	19.0	12.0	15.0	5.6	4.3
60	28.0	17.0	21.0	8.2	5.7
80	37.0	21.0	27.0	11.0	7.5

Figure 2. Data taken from the Nutrient management Guide (RB209). Typical nutrient content of poultry manure (fresh weight basis) AHDB (2023).

My own farm manure analysis (see Appendix C) has shown these figures can vary throughout the year either through climate conditions or even the feed ration fed to the birds. This shows the RB209 nutrient management guide can only be used as a guide, and I would recommend doing your own tests before applying to the land.

4.2 Challenges

Poultry manure is a valuable resource, but it poses several problems stemming from its intense chemical composition, its bulk, which is at least some two thirds water, and its smell.

4.2.1 Storage

Poultry manure can be challenging to manage as it is often a smelly and unstable product to store.

First-hand experience of trying to store the manure under a plastic sheet prove difficult and impractical. Also trying to incorporate straw bedding from cattle or gypsum to stabilise the manure helps but is not a solution.

To be able to store the product efficiently, reduce the build-up of flies and ammonia, the moisture content ideally needs to be reduced and stored in a suitable building.

4.2.2 Environmental impact

Concerns over nitrification and phosphate in the manure have been linked to the pollution of water courses. An example of this in the UK is the river Wye in Herefordshire where there is a large population of poultry in the area that has expanded in a relatively short period of time. There is significant industry pressure to clean the waterways.

Where manure has been tipped, especially over winter, it can damage soils making it unable to grow any productive crop for several years. Farmers who have been spreading poultry manure for a long period of time are now finding that there is too much phosphorus in the soils and they are becoming unsuitable for growing crops.

The UK Environment Agency has established closed periods for spreading manure and procedures for nitrogen vulnerable zones to reduce agricultural pollution risks to water and soils. This also addresses the issue of storing large amounts of manure.

4.3 Summary

- Poultry manure is a highly effective fertiliser.
- Expanding poultry farming has led to an increased quantity of manure.
- Legislation is in replace to reduce the environmental impact.
- Contamination of soils and water courses cannot continue.
- Manure spread on the land must not exceed its nutrient requirement.
- Drier manure has improved nutrient value.
- There is a need to develop technologies for the handling and disposal of poultry manure.
- Own manure analysis can produce more accurate data.

CHAPTER 5: OPPORTUNITIES FOR POULTRY MANURE

During my travels, as well as discussing the poultry industry and the challenges raised by the constant need to manage the manure effectively, I came across some interesting examples of innovation.

5.1 Gran Canaria - an innovative approach to composting.

During my visit to Gran Canaria, I observed a composting process that utilised a biocatalyst which had been developed over several years. This method offered significant advantages; producing compost in just 24 hours and ensuring it was pathogen-free.

Figure 3. Biactro main site and team. *Source: Author's own.*

My guide and translator was Thawani Ritesh, aka Rayco, a contact I met at the John Innis Institute whilst at the Nuffield Contemporary Scholars Conference. He introduced me to Mario Santana and Octavio Hernandez the founders of Biactro. The issue in Gran Canaria was that green waste from the tomato plantations was building up. Octavio, with a doctorate and scientific background, and Mario, who had a tomato plantation, started trials in 2005 investigating the use of waste from tomato plant and turning it into a useful compost. In 2018, with help from local tomato growers, they formed a cooperative to enable them to get a functioning processing plant. With a government grant, they are now processing 2,000 acres of tomato green waste. The new investment enabled them to increase production and process up to 18m^3 per hour through their system.

The process they used was to shred the organic material with a shredder and then have any plastic removed through a trommel rotating cleaning screen. The shredded cleaned material was then passed through a containerised tank filled with bio liquid containing the biocatalyst used to break down the material which was then augured out. This product was then heaped into rows on a concrete pad to provide a stable environment for the enzymes to work over a 24-hour period.

For my visit, they had run some trials with some poultry layer manure they had sourced. The visit prompted them to look at poultry manure as a product that they could blend into their processes.

They found that to make a commercialised product, a carbon element had to be added. Their trials showed that a 70% tomato plant waste: 30% poultry manure was the best blend. Analysis on the end product gave figures of 2% N, 1.5%P, 2.1% K. See Appendix B for the detailed analysis of the results.

Making the biocatalyst was a process that Octavio had developed and I was led to believe it was cultured using worms. He could also customise his product by using different blends of raw material to suit the user.

The process also offered other benefits such as it eradicated any smell, had the potential to process any organic material, and included the potential to process dead stock animals (please note, this had not been trialled).

5.2 Austria/Slovenia manure pelleting

Traveling from Austria to Slovenia, I visited a manure pelleting plant with the Big Dutchman equipment company.

Figure 4. The author and Franz-Josef Straub. Source: Author's own.

Meeting up with Franz-Josef Straub, Product Manager for Big Dutchman, in Graz, Austria, we crossed the border into Slovenia and travelled to Bucecovci. The farm used the Enriched Colony Cage system housing 250,000 layers.

Across Austria and Slovenia, poultry farmers are facing the same challenges as those in the UK, with manure being tipped in fields. They are also keen to find a solution. One farmer had opted for the Big Dutchman Optisec plate dryer with a containerised pellet box and planned to sell the product into garden centres.

This system utilised the warm air extracted from the one of the poultry sheds, regulated to around 20°C and blown over the manure spread across the drying plates. The dryer part of the system is a

conveyor made up of linked plates on multiple levels so as the manure works its way down over a period of three days, it is turned as it drops on to the next layer. The moisture of the manure could be taken from 30 % to 85% dry matter.

When it achieves the correct moisture content, it is fed into the pellet box. The containerised pellet box passes the dried manure though a small hammer mill before entering the pellet press. This press operates at a temperature of 90°C to ensure pathogens are killed. Any manure that passes through the press before it gets to operating temperature is returned to the beginning. The pellets are then put into bulk bags and stored in a dry shed. The pelleted manure product was now able to be stored and then transported off farm. The goal was that the manure would be sold into garden centres, but this market had not been explored at the time of my visit and it was being used on his own arable crops.

The nutrient values of the product were typically around 5% N, 3% P, 3% K. This process enriched the manure and reduced haulage costs.

Franz told me that Vietnam was seeking manure pellets for organic fertiliser due to the country's ban on artificial fertiliser, creating an opportunity to export this product.

5.3 New Zealand - a developing industry

New Zealand has a relatively small poultry industry but it is possibly one of the most progressive farming countries in the world. Not only do they have a disciplined approach to quality standards, but they also face some huge environmental issues.

The poultry farms I visited had modern colony cage systems, multi-tier barn systems as well as free-range equipment, mainly sourced from Europe. Due to New Zealand’s climate having a 10-month growing season, the manure is used as an organic fertiliser and spread on the land by farmers most of the year.

Figure 6. Mainland poultry free range laying site, South Island. Source: Author’s own.

New Zealand has a large population of livestock. The mainly dairy areas I visited are now experiencing the effect of increased water pollution: recently statutory restrictions on the amount of artificial fertiliser used to grow grass were being issued to reduce pollution.

I was invited to speak to the World Poultry Science Association in Nelson: I was asked many questions on how the poultry industry might look like for them in the future from a UK poultry farmer’s perspective.

I also attended the 2023 Nuffield Triennial Conference in Christchurch. This was a good

platform to exchange ideas and share insights facing agricultural sectors and listen to keynote speakers. The conference programme gave me the opportunity to see other sectors including an intense, pasture-based dairy with challenges of water supply and irrigation, as well as visit Fonterra's large-scale dairy factory producing milk powder and cream cheese ready for export.

Even though the New Zealand poultry industry was relatively small, there were still some environmental issues associated with livestock manure. The poultry industry there is only just developing but it seems that they, too, are coming up against similar problems as in other countries with coping with the polluting effects of manure.

5.4 Netherlands

The Netherlands was very interesting and has a large poultry industry and specific legislation on the poultry production. Innovation was widely used to comply with government regulations introduced because of the country's high livestock density.

5.4.1 - an example of drying and storing poultry manure

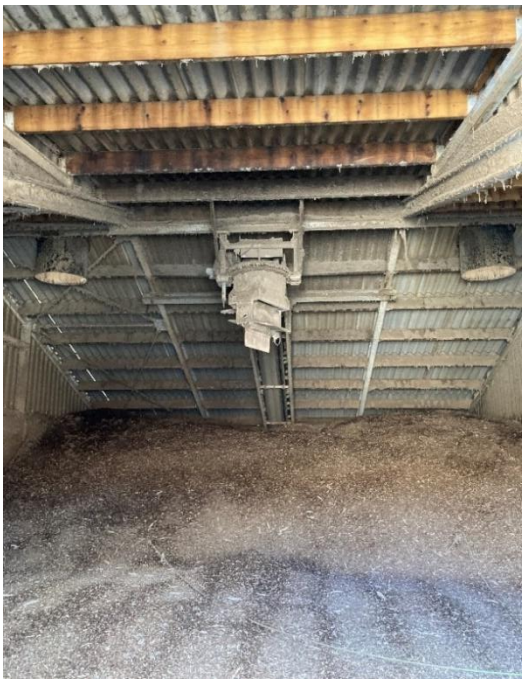

Figure 7. Poultry manure drying floor, showing the heaped manure. *Source: Author's own*

Meeting Klaasjen Solomans provided me with the opportunity to see an exciting, innovative on-farm approach. The site I visited had a 110,000-bird barn layer site and, due to restrictions with manure, it was costing him up to 10 euros a tonne to take the manure away, usually exported to France or Germany.

Over several years, he had developed a relatively low-cost solution to drying and storage of his poultry manure using a very simple drying floor within an enclosed building. By utilising a fan, air is blown though pipes in the floor to create a drying floor with no additional heating required.

The manure was transferred to the shed via conveyors. Klaasjen had developed a spreader on the conveyor to spread the manure evenly over the drying floor. His laying shed had additional air dryers over the manure belts to speed up the drying process; this can take his manure from 40 % to 75% dry matter which is enough to store the manure inside with no flies. The manure is heaped up and by doing this it starts to produce heat. These heaps are monitored so that when a heap reaches 60-degrees in temperature it then

qualifies to be government approved compost that is pathogen free. Throughout this process, the temperature is monitored, controlled and recorded.

The process has enriched the manure by reducing its moisture content, thereby increasing the nutrient concentration per unit of weight. This enhancement allows him to sell the manure at a premium. He plans to implement this concept across other farms with the goal of creating a manure market where manure can be bought and sold as fertiliser through his business platform. His location is strategically positioned to facilitate sales across Europe.

Another benefit from composting is that the heating process ensures that weed seeds in the manure and pathogens are killed.

5.4.2 The Netherlands- an example of using an anaerobic digester with mixed waste

Figure 8. Anaerobic Digestor Plant. Source: Author's own.

I also went to visit Pieter Winter of Agro Giethoorn who uses an anaerobic digestor on farm to provide renewable electric power to the energy market. The farm specialises in growing potatoes, high welfare broiler chickens and a biogas plant.

Figure 8. Anaerobic Digestor Plant. *Source: Author's own.*

The biogas plant was on a large scale and required 52,000 tonnes of feed stock producing power for the national grid and use on farm as well as commercial digestate. The plant is fed on 50% poultry and dairy manure sourced from their own chickens and nearby dairy farms. There was also waste from tulip / onion bulbs, grass cutting from roadsides, salad and milk waste. The plant is fuelled by waste products only so the land could be used for production of food for humans and animals. Producing 45,000 tonnes of digestate, the solids are separated and sold off farm. The liquid was kept and used as a fertiliser on their own farm to aid the growing of crops.

Figure 9. Two large generators running on biogas to produce electricity. Source Author's own

The gas created by the plant was used to power two large generators that produce 1500kwh into the national grid. The heat given off from the engines was also re-used to heat the poultry sheds and heat the digestate to 59 degrees for a period of one hour before it enters the final lagoon to kill off any pathogens. The heat was also used to dry potato waste, then it could be shredded and sold as a starch product for pet food.

5.5 The UK

After examining various challenges and potential solutions in the countries I visited, I wanted to compare these with the research and work being conducted in the UK. Thus, I visited centres and farms to observe their efforts. The UK is actively engaged in research and development related to poultry manure and applied technologies, supported by a substantial poultry industry that operates under stringent environmental and welfare standards.

5.5.1 Harper Adams University - integrating novel technologies

Figure 10. Marie Kirby in front of a micro digester. *Source: Author's own*

I visited Harper Adams University to meet senior lecturer Marie Kirby, who focuses on integrating novel technologies. Marie demonstrated a small-scale anaerobic digester to show that anaerobic digestion can be adapted for manageable on-farm use. The dairy industry funded this project.

The subsequent phase of research focused on extracting nutrients from the digestate derived from manure, with the potential to formulate customised fertilisers that could serve as substitutes for synthetic fertiliser. These fertilisers can be applied to soils that exhibit nutrient deficiencies. For instance, nitrogen can be extracted using Biochar filters, with initial trials demonstrating a recovery rate of

96.6% nitrogen. Electrocoagulation has proven effective in recovering 95% of phosphorus. Although these techniques are presently utilised within the dairy industry, their applicability may extend to poultry manure.

Marie believes that bio digesters are essential for producing biofuels like bio methane, hydrogen, and bio plastics. She participated in a group at Harper Adams University and the School of Sustainable Food and Farming (SSFF), producing a report on novel methods for valorising chicken manure. The report explored reducing pollutants and contaminants using various substances on chicken litter and the potential of membrane-microbial fuel cell technology to use poultry manure as a biological battery.

5.5.2 Whittern Farms - litter burners

During my recent visit to Whittern Farms in Herefordshire, I had the opportunity to meet with James Write, the Farm Manager, to gain insights into the newly installed litter burners. The farm has implemented three litter burners as replacements for the older woodchip boilers used to heat their broiler farms. The decision was made to utilise the poultry manure produced on the farm as a fuel source. This approach is well-suited for broiler production due to the typically dry and stable nature of the manure throughout the birds' rearing period. This strategy significantly reduces the need to export manure from the farm and eliminates the necessity to import approximately 4,000 tonnes of woodchip previously required by the older boilers.

Figure 11. BHSL fluid bed incinerator. *Source: Author's own*

The manure from the birds is placed in a shed where an autoloader can feed the boiler. The boiler is a fluid bed type where the manure is burnt on a bed of sand and produces heat upwards of 800°C to incinerate any dangerous exhaust fumes. The ash produced at the end can be bagged and sold into fertiliser production.

Once the litter burner is up to operating temperature it cannot be stopped so any excess heat it just vented outside into the atmosphere. James recognises this is a waste and is now looking into uses for ways to utilise the heat waste, e.g. use the excess waste for drying or heating alternative products.

5.6 Summary

- Proven concepts are becoming more viable for handling waste manure.
- Technology has provided a separate income stream to justify investment.
- Solutions are available regardless of scale of operation.
- New concepts are in development leading to more opportunities in the future.
- Dealing with organic waste is an international problem and these applied technologies could be suited to different industries.

CHAPTER 6: DISCUSSION - OPPORTUNITIES FOR POULTRY MANURE

6.1 Opportunities

Researching opportunities and adding value to many poultry manures produced by the broiler and layer industry is key. Having similar nitrogen, phosphate and potash values on a dry weight basis the composition is very different. The broiler manure is generally dryer with a 60% dry matter content as opposed to the layer manure with a dry matter content of around 30%. This makes handling and storage of the broiler manure much more manageable than layer manure.

Poultry manure is nutrient-rich and can be utilised as an organic fertiliser that also serves as a biological soil improver. This concept of using poultry manure as a fertiliser for crops can be further advanced by composting the material. Composted poultry manure can enhance nutrient ratios by reducing moisture content and eliminating pathogens. Composting involves the decomposition of organic material which, although a slow process, can be accelerated by regularly turning the compost. If composting is conducted outdoors, it may lead to environmental concerns such as water runoff. However, these issues can be mitigated by using a more compact vessel-type composter.

Another form of using poultry manure as fertiliser would be to dry and pellet the manure which produces an easy to apply product with reduced transport cost and easier handling.

Dry poultry manure has a high calorific value, which allows it to be used as a fuel for energy production. Heat and electrical energy can be generated with technology that can be implemented on farms or sold to large-scale power stations.

The product can be burned producing heat for hot water and pumped to where it is required or used to drive a turbine for electrical energy.

Burning the manure does take away a valuable resource of nitrogen and organic matter which may be better suited for crop production.

Poultry manure can even be used as a feed stock for biogas plants giving the ability to produce biogas. This gas can be then used to power generators for electrical energy leaving a digestate as a product that can also be used as a source of organic fertiliser.

Summary of opportunities

- Poultry manure can be used as a fertiliser and soil improver when applied correctly.
- Poultry manure can be used as a fuel source.
- More processed poultry manure means less reliance on artificial fertiliser.

- Processing can offer volume reduction and increased nutrient levels.

6.2 Are there any game changers

Through travels and research, it was shown that there is a known challenge that needs addressing. Some innovative processes are being explored, such as using manure to produce energy and custom-made fertilisers.

The idea that stood out as a game changer for me was Klaasjen Solomans manure drying floor. It provided an economical on-farm solution for long-term storage, suitable for smaller-scale producers.

Due to the complex composition of poultry manure and the varied configurations of poultry businesses, each enterprise will need to adapt the technology in a unique manner. A single solution is unlikely to be effective for the entire industry. Consequently, multiple solutions should be provided.

6.3 What could the poultry industry do to clean up

An integral part of running a poultry business is to be aware and educated on the challenges we face and the options that can be taken to mitigate them. On my travels and from my own experience, there are more actions needed by the industry itself, the research sector and government. This can be done in the following ways:

- Industry bodies should come together to educate and share knowledge on options.
- Clearer industry legislation with support available to businesses.
- Further funding into Research & Development to continue innovation.
- Assessments available for poultry businesses to identify any opportunities and commercial benefits e.g. processing manures could offer a commercial benefit by creating a controlled manure market offering enriched pathogen free product.

CHAPTER 7: CONCLUSIONS

1) Every poultry enterprise is managed differently and one solution may not benefit others.
2) Manure from the broiler industry, being generally dryer, maybe be better suited to energy production and manure from layers used for fertiliser.
3) Areas with a higher poultry population and tighter legislation leads to innovation.
4) Poultry manure is not a waste product and value can be added.
5) Poultry manure cannot be stored outside for long term periods without having environmental impact.

CHAPTER 8: RECOMMENDATIONS

Developing and understanding new technology requires new skills.Demonstrate best practice within the legislation required and the geological location impacting on the business.

Demonstrate best practices in accordance with relevant legislation and consider the influence of local geological conditions when using poultry manure in the business

1) The ideal technology would have to have the ability to pay for itself and even offer a return on the initial investment.
2) Grants and incentives should be made available to help fund technology that can demonstrate environmental benefits.

CHAPTER 9: AFTER MY STUDY TOUR

My Nuffield Farming scholarship has given me a great opportunity for personal development as well as to meet new people here and internationally.

The scholarship has enhanced my skills and boosted my confidence. I found myself in new situations, such as waiting at an airport in Graz, Austria for a contact to pick me up. I also spoke on stage in front of the World Poultry Science Association (WPSA) in New Zealand, sharing my views on UK poultry farming.

I hope to develop ideas I have seen during my study tour not only in my chosen study topic but for my industry, giving me a more rounded view of the poultry industry.

A drying floor storage solution similar to the one in the Netherlands is planned for implementation on my family farm. This approach provides long-term storage with minimal labour requirements and is cost-effective for on-farm operations. It allows the business to manage and sell the byproduct without spreading manure in the fields.

CHAPTER 10: ACKNOWLEDGEMENTS AND THANKS

The Nuffield scholarship programme has consistently provided assistance, encouragement, and guidance. Additionally, gratitude is extended to the farms and businesses that have contributed their time to my study tour.

I would like to thank my wife, Emma, for her support and parents, Stephen and Trish, for covering while I have been away on my study tour. This at times has not been easy in a family farming business.

Thank you to Rufus Pilgrim for being my Nuffield mentor for his guidance and for checking in on my progress throughout the scholarship program.

Many thanks also to Lorna Garnett. Whilst I was in New Zealand, Lorna went out of her way to put together a great itinerary in a short time.

I would like to thank the British Egg Marketing Board Trust and trustees for making my Nuffield scholarship possible.

CHAPTER 11: REFERENCES

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Marie Kirby a novel nitrogen removal technology upload.pdf

Nutrient management Guide (RB209), AHDB (2023): https://ahdb.org.uk/nutrient-management-guide-rb209

Storing organic manures in nitrate vulnerable zones: www.gov.uk/guidance/storing-organic-manures-in-nitrate-vulnerable-zones

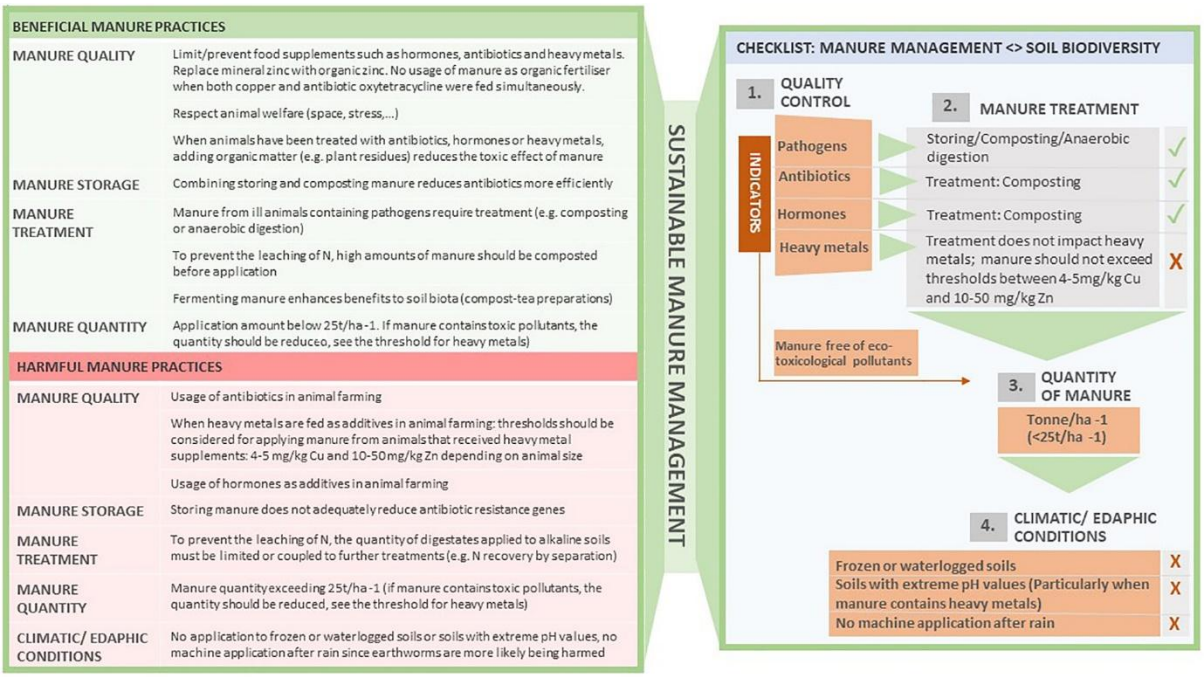
Manure & Soil Biodiversity:

Manure and soil biodiversity - ESDAC - European Commission

CHAPTER 12: APPENDIX PARTS A, B, C, D

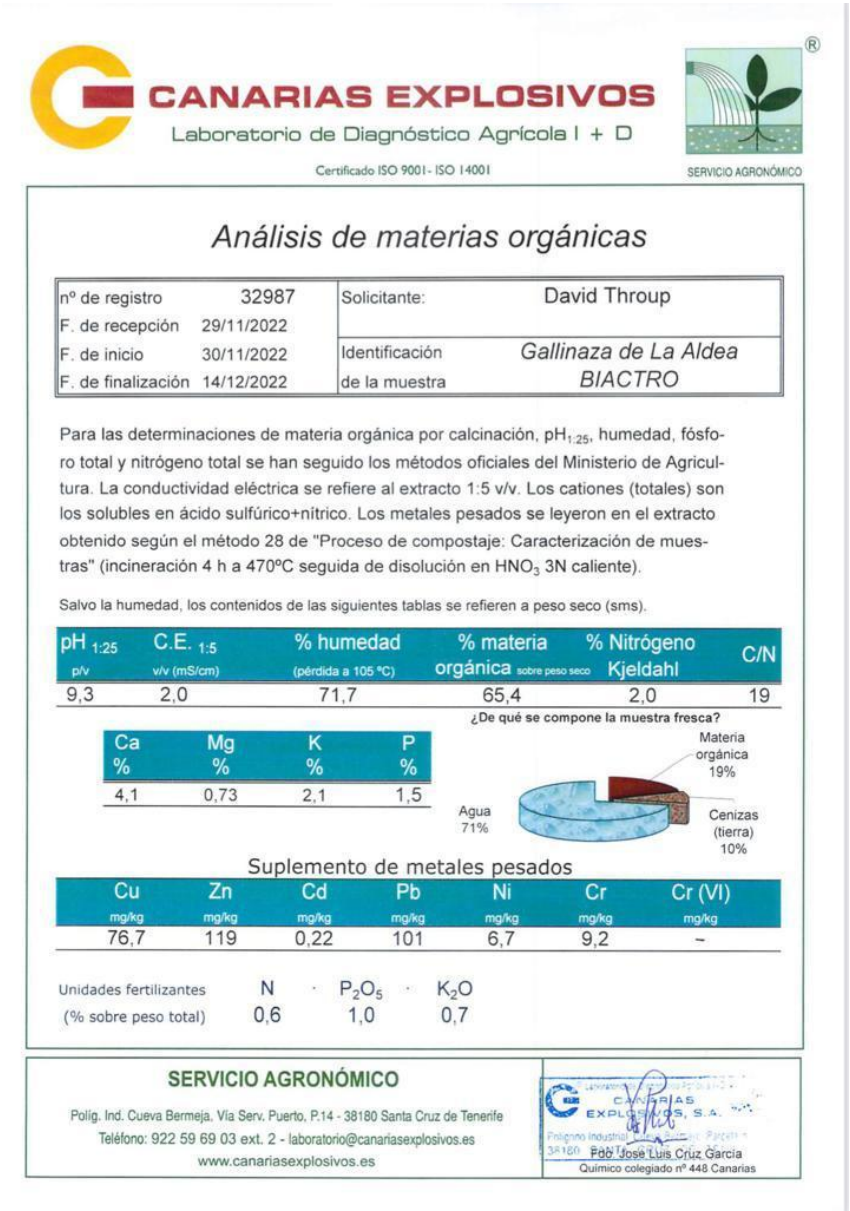
A. Manure and soil biodiversity in Europe

Beneficial and harmful manure practices for soil biodiversity (on the left) result in sustainable manure management:



Manure and soil biodiversity - ESDAC - European Commission

B. Lab test results of the composting process from Gran Canaria



CANARIAS EXPLOSIVOS
Laboratorio de Diagnóstico Agrícola I + D
Certificado ISO 9001 - ISO 14001
SERVICIO AGRONÓMICO

Análisis de materias orgánicas

nº de registro	32987	Solicitante:	David Throup
F. de recepción	29/11/2022		
F. de inicio	30/11/2022	Identificación	*Gallinaza de La Aldea*
F. de finalización	14/12/2022	de la muestra	*BIACTRO*

Para las determinaciones de materia orgánica por calcinación, $pH_{1:25}$, humedad, fósforo total y nitrógeno total se han seguido los métodos oficiales del Ministerio de Agricultura. La conductividad eléctrica se refiere al extracto 1:5 v/v. Los cationes (totales) son los solubles en ácido sulfúrico+nítrico. Los metales pesados se leyeron en el extracto obtenido según el método 28 de "Proceso de compostaje: Caracterización de muestras" (incineración 4 h a 470ºC seguida de disolución en HNO_3 3N caliente).

Salvo la humedad, los contenidos de las siguientes tablas se refieren a peso seco (sms).

pH 1:25 p/v	C.E. 1:5 v/v (mS/cm)	% humedad (pérdida a 105 ºC)	% materia orgánica sobre peso seco	% Nitrógeno Kjeldahl	C/N
9,3	2,0	71,7	65,4	2,0	19

Ca %	Mg %	K %	P %
4,1	0,73	2,1	1,5

¿De qué se compone la muestra fresca?

Suplemento de metales pesados

Cu mg/kg	Zn mg/kg	Cd mg/kg	Pb mg/kg	Ni mg/kg	Cr mg/kg	Cr (VI) mg/kg
76,7	119	0,22	101	6,7	9,2	–

Unidades fertilizantes (% sobre peso total)	N	P_2O_5	K_2O
	0,6	1,0	0,7

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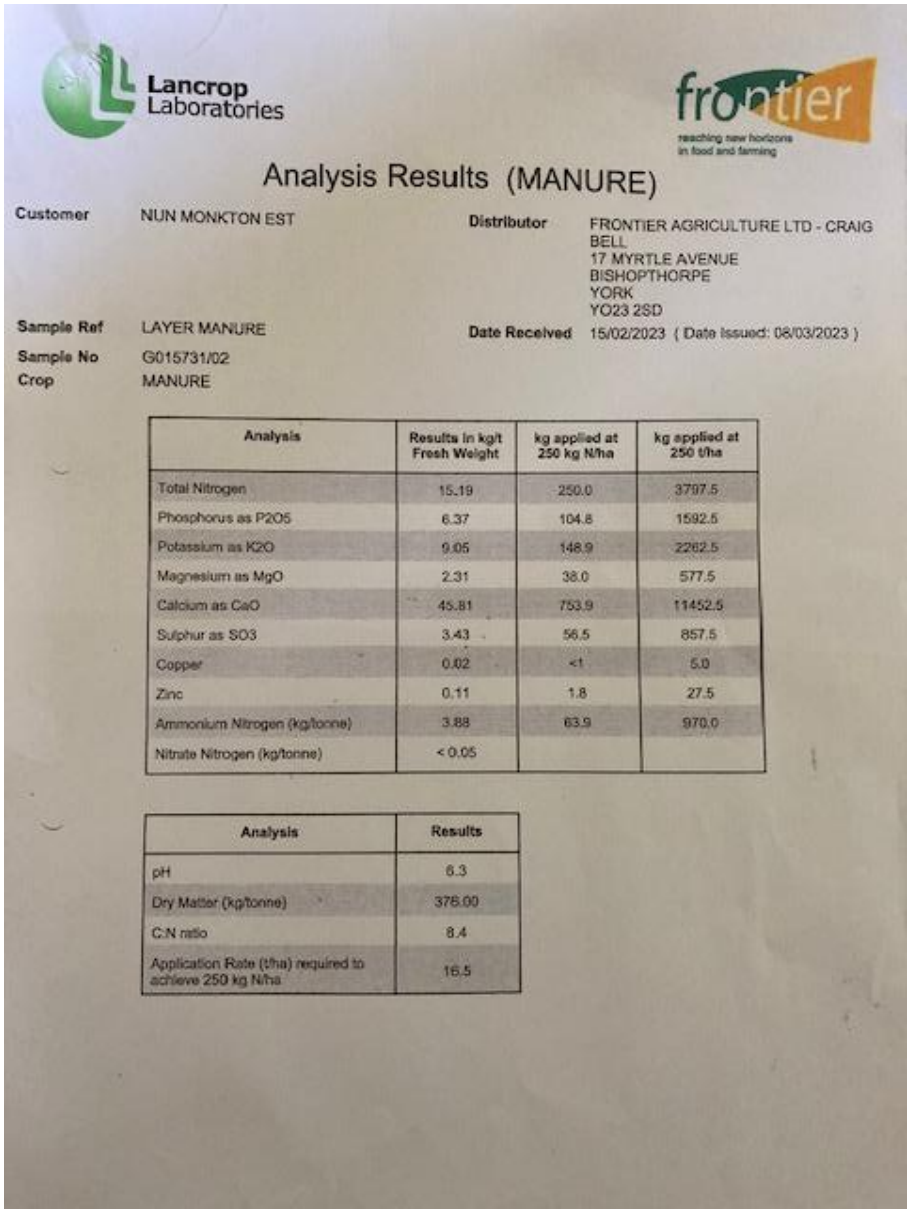
www.canariasexplosivos.es

CANARIAS EXPLOSIVOS, S.A.
Pdo. José Luis Cruz García
Químico colegiado nº 448 Canarias

C. Own farm manure results for layer manure



Lancrop Laboratories

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Analysis Results (MANURE)

Customer NUN MONKTON EST

Distributor FRONTIER AGRICULTURE LTD - CRAIG BELL
17 MYRTLE AVENUE
BISHOPTHORPE
YORK
YO23 2SD

Sample Ref LAYER MANURE

Date Received 15/02/2023 (Date Issued: 06/03/2023)

Sample No G015731/02

Crop MANURE

Analysis	Results in kg/t Fresh Weight	kg applied at 250 kg N/ha	kg applied at 250 t/ha
Total Nitrogen	15.19	250.0	3797.5
Phosphorus as P2O5	6.37	104.8	1592.5
Potassium as K2O	9.05	148.9	2262.5
Magnesium as MgO	2.31	38.0	577.5
Calcium as CaO	45.81	753.9	11452.5
Sulphur as SO3	3.43	56.5	857.5
Copper	0.02	<1	5.0
Zinc	0.11	1.8	27.5
Ammonium Nitrogen (kg/tonne)	3.88	63.9	970.0
Nitrate Nitrogen (kg/tonne)	< 0.05		

Analysis	Results
pH	6.3
Dry Matter (kg/tonne)	376.00
C:N ratio	8.4
Application Rate (t/ha) required to achieve 250 kg N/ha	16.5

D England: Nitrate Vulnerable Zones legislation

Nitrogen Vulnerable Zones (NVZs) are designated areas that are at risk from agricultural nitrate pollution. They include about 55% of the land in England and limit the amount nitrogen per hector to 170kg per year. These rules are enforced by the Environment Agency and if the landowner does not comply, they can be fined or even prosecuted.

Temporary field manure storage within the NVZ can be done but must follow certain criteria such as:

- Be 10 metres from any surface water.
- A location not liable to flood.
- 50 metres away from a well or borehole
- Heaps to be moved every 12 months.
- A two-year gap before returning to the same site.
- Records to be kept of the location and dates of the field heaps.

Within the NVZ there is also a closed period for spreading poultry manure on the land and ranges from 15 October to the 31 January. Farms which are located outside an NVZ should follow a code of good agricultural practice, which are guidelines put in place to reduce ammonia emissions from the storage and application of manures.

www.gov.uk/guidance/storing-organic-manures-in-nitrate-vulnerable-zones

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