

# Farm Effluent Management

**How to utilise the nutrients from dairy herd  
manure to improve a biological farming system**

A report for



By John Keely

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# Executive Summary

Legislators in many countries have recognised the importance of increasing community and industry expectations in order to protect the environment. Understanding the management of effluent and manure on farms is critical to the sustainable management of the rural environment and potentially improving the productivity and profitability of farms.

This Nuffield report considers the effluent management practices being employed in other countries and the regulations which frame these practices. The author visited the UK, Ireland, Denmark, the Netherlands, USA, New Zealand, Belgium, Germany and Canada. The author met with and interviewed farmers, researchers from industry and universities, as well, as observing a variety of farms on their innovative use of effluent and manure. Where practices have achieved success, and vary from those commonly occurring in Australia, this is mentioned in this report.

Australian on-farm environmental regulations appear to be less rigorous than some countries, which may be in part due to extensive land mass, size of farms and lower soil fertility. In comparison to most EU countries, Australia doesn't have the same level of intensity. Farms are larger with readily available land on which to spread effluent and manage manure. Also, the environmental tensions caused by urban spread into former rural land are not as prevalent as some EU countries.

The European Union has implemented extensive regulations in their countries and their farmers have complied and sought local solutions with regards to their concerns. In Denmark and the Netherlands, and to a lesser extent the UK, farming intensive small holdings, science and technology has been used to develop unique solutions to managing effluent and manure. Industry and university research has contributed to this by assisting farmers with solutions to crop application of effluent and effective strategies to improve soil health.

In the United States, the Environmental Protection Agency (EPA) has regulated a Nutrient Management Plan which requires farmers to meet a set of nine minimum standards. The compliance regulations vary between States. Generally, for larger Concentrated Animal Feed Operations (CAFO's) these are mandatory and strictly regulated. For smaller holdings NMP's are encouraged by State authorities but not necessarily mandated. Contrast this with the regulations of the EU where non-compliance by farmers can result in very large fines.

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# Foreword

As a fifth-generation dairy farmer from Cohuna in Northern Victoria, the Keely family operate a milking herd of 310 cows calving in both autumn and spring. Their calving herd has a 40/60 split; 40% in the autumn and 60% in the spring. They are self-sufficient in hay and silage conservation. All pastures and crops are flood irrigated. Biological farming practices are being implemented on a gradual basis as part of the long-term farm management strategy.

The property has been in the Keely family since 1874, and what was appropriate farming practice then may not be so relevant today. The vision for the farm is building sustainable farm management practices with increased efficiencies and productive capacity which contributes to improved income.

There is a need to have more flexible farming management systems which are adaptable to climate variability, more environmentally sustainable and less reliant on chemical-based fertilisers. As dairy farming operations become larger there is a tendency for them to become more intensive in the way animals are contained and fed.

This Nuffield Scholarship has provided an opportunity to research the best international sustainability practices being implemented on farms around the world, with a special emphasis on how farmers are managing their effluent and manure.

# Acknowledgements

This Nuffield Scholarship has provided an opportunity to investigate innovative effluent and manure management on farms around the globe viewing agriculture from a different perspective. Nuffield Australia and the Gardiner Foundation has provided a once in a lifetime learning experience.

This report could not have been possible without the support of the farmers, agricultural advisors, researchers and extension staff along with fellow scholars that generously shared their time and experiences to form the basis of this report. These are way too numerous to mention individually.

To Damien Murphy, Adam Jenkins and Paul and Lisa Mumford a huge thanks. Damien, without his encouragement this incredible journey would never have occurred. The counsel of Adam throughout the application process was of great assistance and extremely beneficial throughout each stage. The support of Paul and Lisa Mumford, particularly during the GFP was fantastic.

The invaluable assistance of Ron Page and John Brookshaw was appreciated for efforts in writing this report.

Special thanks should go to my wife Michelle Keely who firstly shelved her own planned family adventures and encouraged and supported this incredible experience. After the GFP Michelle learned more about manure than she probably ever imagined she would or cared for. She then translated the hand-written notes into a legible format allowing this report to come together so much easier. Harrison, our youngest son, was left at home to manage the farm in the wettest and most trying of conditions for more than 40 years. He did a magnificent job supervising and managing the farm during travel absences, with the support of his grandparents Des and Elizabeth and employee Steve.

Finally, to fellow Nuffield GFP members Matt Abbott, Jessica Bensemman, Adam Coffey, Clair Doan, Ben Edser, Ray Hunt, Luke Mancini and Debbie McConnell. What a blast! It was the camaraderie and mutual support that has made this Nuffield experience one that will be valued forever. The countless hours sharing ideas, discussing and developing strategies for improving agriculture and enjoying each other's company.



**Figure 1:** India Global Focus Programme Group (GFP)

# Abbreviations

ASABE	American Society of Agricultural and Biological Engineers
bu	bushels
CAFO	Concentrated Animal Feeding Operation
CCF	Clynderwen & Cardiganshire Farmers Ltd
DM	Dry Matter
EPA	The United States Environmental Protection Agency
EU	European Union
GFP	Global Focus Program
K	Potassium
K <sub>2</sub> O	Potassium Oxide
MAP	Mono-Ammonium Phosphate
N	Nitrogen
NMP	Nutrient Management Plan
NPDES	National Pollutant Discharge Elimination System
NRFV	Nitrogen Fertiliser Replacement Value
NVZ	Nitrate Vulnerable Zones
NH <sub>3</sub>	Ammonia
P	Phosphorus
P <sub>2</sub> O <sub>5</sub>	Phosphorus Pentoxide is a chemical compound
pH	(potential of hydrogen) is a scale of acidity from 0 to 14.
PMR	Pembrokeshire Machinery Ring
SDA	Sustainable Dairy Advisors
UAN	Solution of urea and ammonium nitrate in water used as a fertiliser
USDA	United States Department of Agriculture



# Objectives

1. Investigate international practices to better utilise the nutrients from manure and effluent as part of a biological farming system.
2. Investigate how effective biological practices translate into improved management practices.
3. Investigate how regulations can impact on these practices.

# Chapter 1: Background

Most dairy production is located in coastal areas where pasture growth generally depends on natural rainfall. Nevertheless, there are several inland irrigation schemes, most notably in inland northern Victoria and southern New South Wales.

Falling farm numbers do reflect a long-term trend observed in agriculture around the world, as reduced price support and changing business practices have encouraged a shift to larger, more efficient operating systems.

Average herd size has increased from 93 cows in 1985 to an estimated 284 currently. There is also a steady trend emerging to very large farm operations of more than 1,000 head of dairy cattle". (Dairy Australia, 2017)

The author believes the dairy industry particularly in Northern Victoria is becoming more intensified. The use of feed pads and loafing areas as part of the management system has seen vast amounts of manure quickly build up in a small area. Applying this directly to pastures in its raw form can present a number of problems. These include weed control and the leaching of nutrients, as well as, run off from irrigation and significant rain events.

More sustainable methods of applying these products to pastures are needed. Livestock producers have a valuable asset at their disposal and it needs to be managed more effectively. By using the effluent and manure in a more productive and skilful fashion, the potential of pollution to water ways is reduced as well as the need to purchase crop fertilisers.

The regulations governing the management of farming practices between states, involves a complex web of regulations that include Councils, The Department of Economic Development, Transport and Resources, (State Government), Catchment Management Authorities, Environment Protection Authority and local Water Authorities.

# Chapter 2: Regulation

## Cattle Empire, Kansas, United States of America

According to Roy Brown from Cattle Empire, this is one of the largest family owned cattle feeding organisations in the United States. They have a total one-time capacity of 245,500 head of cattle in five feed yards all located in Haskell County in Southwest Kansas. The ownership group consists of two generations of the Paul Brown Family. The company is managed with a team approach, led by Roy Brown, Chief Executive Officer, Dr Tim Murphy, Chief Operations Officer, Lucas Christensen, Chief Financial Officer and Trista Brown Priest, Chief Strategy Officer.

They are very proud of their tradition, the organisation, their people and the industry. They strive to produce the finest beef found anywhere in the world in an economical and sustainable fashion while always keeping the welfare of the livestock as being the highest priority. (Brown, N. Roy)

Cattle Empire is bound by the Federal Authority of the United States EPA and the State authorities of Kansas. Compliance with Federal and State authorities is documented in a Nutrient Management Plan (NMP) as required by the Environmental Protection Agency. Nutrient Management Plans are precise plans detailing the quality of land, water, manure and air around the enterprise. (Brown, Roy N)

Each of these resources is measured on an annual basis to ensure the integrity of the resource. The State will enforce the Federal regulations but can also impose other regulations which can be more stringent than the Federal regulators. The Federal authorities are rarely seen but the State authorities visit every twelve to eighteen months. Part of these regulations state that all rain water run-off falling on manure, fodder, stored raw commodities or finished feed potentially being contaminated has to be collected into waste water pits. There are parameters that have to be met, such as being able to contain all run off from a once-in-a 25-year, 24-hour storm event which equates to 4.7 inches (118mm) in 24 hours for the Satanta, Kansas area. The State issues a permit if the business has over 1,000 head of cattle (there are currently 80,000 at this facility). Each facility has to supply to the State authority, a plan set, which is an engineering design, with appropriate calculations. The permit describes all the waste water structures in place and any kind of sediment control prior to the run off entering the main storage pond. The amounts of sediment being trapped are important, as the volume of the pond can be reduced if this is not trapped. Ponds are expensive to clean out. If the state is satisfied with all conditions being met they will issue a permit. A condition of the permit is that a certain amount of space is required to be maintained at all times to cater for extreme weather events. If this event occurs and there is not the required amount of space in the pond then it must be de-watered by pumping it onto cropping land via centre pivots.

The Nutrient Management Plan requires effluent to be nutrient tested on an annual basis. There were initially nine minimum standards required by the EPA:

1. Ensuring adequate storage of manure, including procedures ensuring proper O&M of the storage facility.
2. Managing mortalities to ensure that they are not disposed of in a liquid manure, stormwater, or process wastewater storage or treatment system that is not specifically designed to treat animal mortalities.
3. Ensuring that clean water is diverted, as appropriate, from the production area.
4. Preventing direct contact of confined animals with waters of the U.S.
5. Ensuring that chemicals and other contaminants handled on-site are not disposed of in any manure, litter, process wastewater, or stormwater storage or treatment system unless specifically designed to treat such chemicals and other contaminants.
6. Identifying appropriate site-specific conservation practices to be implemented, including as appropriate buffers or equivalent practices, that control runoff of pollutants to waters of the U.S.
7. Identifying protocols for appropriate testing of manure, litter, process wastewater, and soil.
8. Establishing protocols to land apply manure, litter, or process wastewater in accordance with site-specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients in the manure, litter or process wastewater.
9. Identifying specific records that will be maintained to document the implementation and management of the minimum elements described above.

Source: NPDES Permit Writers' Manual for CAFOs

Cattle Empire has fields where the nutrient values in their soils were excessively high. These fields cannot have wastewater applied. So, their solution is to find more ground on which to spread their waste water. It is important to negotiate with neighbours or find other ground that is available. The State deals with some of these issues where farmers are land locked or the neighbours won't cooperate. Crop strategy now plays a significant part in planning.

## **Adams Organic Dairy Farm, Wisconsin, USA**

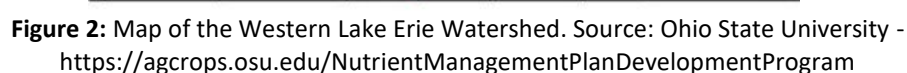
Paul Adams from Adams Dairy, is certified for crops and livestock by Nature's International Certification Services. The dairy has met the requirements of the National Organic Program and is certified by the USDA organic regulations." (Certification Certificate, Natures International Certification Services)

*"It's important to keep the moisture levels in balance as too wet can create health issues. One third of milking herd is in a compost barn. Two thirds are in free stalls on waterbeds with some having recycled bedding on them." (Adams, 2016)*

Trying to get the compost onto the lighter ground is more preferential to the heavier soils. Getting manure back out there for the nutrients is changing things.

Every farmer will have one, be it on paper or in his head, but balancing nutrients is where they are headed. As time goes on there is greater likelihood that it will need to be documented. Paul had been paying for it to be done but at \$4000 per year he quit doing it.

## Ohio State Extension Environmental & Manure Management, Ohio



In August 2014, the Toledo water crisis took place. With an algae bloom in Lake Erie nearly working its way over to the city of Cleveland. It is known the amount of nutrients travelling down out of Canada and what comes in through the Maumee River, and the other rivers that enter Lake Erie. The Maumee River watershed touches 24 of Ohio's 88 counties. This watershed accounts for approximately 40% of all nutrients that enter Lake Erie. There is a smaller lake in Ohio called Grand Lake St Marys. It's very shallow (4ft deep) and 20,000 acres (8100 hectares) in size and has had tremendous algae problems for a number of years. Very high phosphorus levels in the soil have built up primarily by the over application of manure. In Lake Erie the tourism industry is worth about \$10 billion/year which translates to a lot of political clout, with a lot of legislators.

***"Behind Toledo's Water Crisis, a Long Troubled Lake Erie***

*TOLEDO, Ohio — It took a serendipitous slug of toxins and the loss of drinking water for a half-million residents to bring home what scientists and government officials in this part of the country have been saying for years: Lake Erie is in trouble and getting worse with each year.*

*Flooded by tides of phosphorus washed from fertilised farms, cattle feedlots and leaky septic systems, the most intensely developed of the Great Lakes is increasingly being choked each summer by thick mats of algae, much of it poisonous. What plagues Toledo and, experts say, potentially all 11 million lakeside residents, is increasingly a serious problem across the United States.*

*But while there is talk of action — and particularly in Ohio, real action — there is also widespread agreement that efforts to address the problem have fallen woefully short. And the troubles are not restricted to the Great Lakes. Poisonous algae are found in polluted inland lakes from Minnesota to Nebraska to California, and even in the glacial-era kettle ponds of Cape Cod in Massachusetts.*

*Algae fed by phosphorus run-off from mid-America farms helped create an oxygen-free dead zone in the Gulf of Mexico last summer that was nearly as big as New Jersey. The Chesapeake Bay regularly struggles with a similar problem.*

*When Mayor D. Michael Collins told Toledo residents on Monday that it was again safe to use the city's water, he was only replaying a scene from years past. Carroll township, another lakefront Ohio community of 2,000 residents, suspended water use last September amid the second-largest algae bloom ever measured; the largest, which stretched 120 miles from Toledo to Cleveland, was in 2011. Summertime bans on swimming and other recreational activities are so routine that the Ohio Environmental Protection Agency maintains a website on harmful algae bloom.*

*Five years ago this month, the federal Environmental Protection Agency and state water authorities issued a joint report on pollution of the nation's waterways by phosphorus and other nutrients titled "An Urgent Call to Action".*

*Unfortunately, very little action has come from that,' said Jon Devine, the senior lawyer for the water program at the Natural Resources Defence Council in Washington." (New York Times 5 August 2014)*

Nutrient management plans are not required in Ohio but are recommended. In Ohio, a plan is not needed for a farm until there are 2500 pigs, 700 dairy cows or 1000 beef cows. Almost all hog buildings are 2400 hogs per buildings and so on. There is a tendency to go and build elsewhere to avoid submitting a Nutrient Management Plan.

## **Jordanstan Hall, Pembrokeshire, UK**

According to Mansel Raymond, farming at Jordanston Hall; Denmark and the Netherlands are widely recognised as being at the forefront of science technology because politically they have no choice.

It is hard placing a specific value on manure because there is a correlation with fertiliser prices coming down. It is driven by cost. It will be the political and environmental regulations that will drive farmers to utilise effluent. Limits on the amount of slurry and nitrogen that can be applied on land are going to become more stringent.

NVZ (Nitrate Vulnerable Zones) are already in place in Denmark, the Netherlands and parts of England.

*"If land is in an NVZ, you must follow the legal requirements which apply to NVZ's:*

- *Using nitrogen fertilisers in nitrate vulnerable zones*
- *Storing organic manures in nitrate vulnerable zones"*

*(Nutrient management: Nitrate Vulnerable Zones, Department for Environment, Food & Rural Affairs and Environment, Feb 2017)*

This could be catastrophic for very large herds. They will need to look to outside sources to dispose of the effluent. Investment will be required to increase the capacity of effluent storage capable of holding five months' worth with most, currently only having capacity for two months.

## **Blue Flag Farming Partnership, Pembrokeshire, UK**

Blue Flag Farming Partnership is a collaborative program developed by UK milk processing company First Milk, Natural Resources Wales, Puffin Produce Ltd, Pembrokeshire Machinery Ring (PMR) and Clynderwen & Cardiganshire Farmers Ltd (CCF). It is currently in the concept stage and aimed at averting a Welsh Government NVZ proposal. The group sees their program as a partnership approach to delivering positive environmental outcomes through earned recognition. Presently the Welsh Government are consulting on options for the future designation of nitrate vulnerable zones. The EU nitrates directive requires an action programme to be developed. The purpose of the directive is to control and reduce

water pollution from agricultural sources. Currently, it is estimated that 2018 tonnes of nitrogen is entering the Milford Haven waterway from agricultural land. The Welsh Government as part of their NVZ proposal will see the designation of the Milford Haven as a NVZ. Farmers would have to take the following measures:

- Controlled dates when organic and commercial fertilisers may be applied.
- Increased storage capacity for organic manures.
- Limited application rates.
- Limited application methods.
- Increased record keeping.

First Milk in Haverfordwest is successfully running an offset scheme as part of its operating permit. Farmers are able to select from a suite of mitigating measures, the impact of which can be modelled through the ADAS Farmscoper model. (ADAS Services, 2017)

The system is recorded, audited and meets the strict Environmental Permitting Regulations and Habitats Regulation, 30 farmers participating in this program now are saving one tonne of nitrate each from entering the Milford Haven waterway. With 1,800 farm holdings within the catchment and being part of the scheme and reducing their losses by one tonne each there is a potential 89.19% reduction in N offset. Welsh government modelling of NVZ targets are 10%. By being part of the program, the farmers display a Blue Farm gate flag ensuring they are receiving public and industry recognition. There are less regulatory visits and the potential to access ECO Bank funding. The capital cost of Blue Flag is a fraction of the Welsh Governments proposal, which would be £200 million (\$A344 million) Farming groups are worried that it is easier for the government to legislate than allow farmers to self-regulate. EU fines for no action are massive.

## **Wageningen University, The Netherlands**

According to Oena Oenema (Professor in Nutrient Management and Soil Fertility) of the Wageningen University, The Netherlands is at the extreme end of intensification. It is ranked 130 in terms of size but number two in agricultural exports. They are exporting high value products. They are ranked fifth in the EU for imports. They import products, give value to it through processing, and then export it. The whole animal production sector has benefited from this trade. Overtime they have been able to make cheap concentrates. The ability of feed processing companies to source various products and mix and process them into high quality feed at a low price has been a huge stimulus for the intensification of agricultural production. This started in the 1950's after WWII and continued until the mid-1980's. It became clear that this steep increase in animal production could not continue. Uncontrolled manure emissions to air and surface waters caused the development of the Manure Policy in 1984.



Pig feed had high traces of copper in the feed to assist with health and growth of the animal, but this resulted in copper levels reaching toxic levels in grass and soils where the farmers had applied raw pig slurry to the pasture. It was then discovered that applying excess slurry also caused the soils to become saturated with phosphorus. The excess phosphorus leached into the groundwater or travelled to surface water where it adversely impacted the water body

The first phase of the Manure Policy was to tackle phosphorus levels. Policy focus started in 1985. In 1991, the Nitrates Directive (EU) focussed very much on nitrate leaching. So, the first policies focused on nitrogen. This policy was aimed at stopping the further growth of animal production by installing production ceilings based on the amount of manure produced. In the 1990's it was transferred to what is now known as production rights. All farmers must have production rights. These production rights are based on the amount of phosphorus that is excreted in the manure.

The second phase has been a stepped process of reducing the manure burden by limiting farmers' application of phosphorus and nitrogen. The phosphorus limits are determined by the Netherlands whilst nitrogen limits are determined by the EU Nitrates Directive. The subsidised manure distribution system took manure from the south and east of the Netherlands to the north and west. After time the subsidies were removed.

The third phase was balanced fertilisation whereby output balance between manure production and manure use occurs. The Netherlands is still in this phase, as the environmental targets have not yet been achieved.

There have been improvements: the on-and-off farm manure processing has resulted in this becoming an export product, development of feeds with less phosphorus content which decreases the potential for this element leaching into ground or surface water, and the upgrading of animal manure to an artificial fertilizer.

Nitrogen and phosphorus concentrations in service waters are still high in many areas particularly the western part of the Netherlands. There is pressure on farmers from the European Commission and the Netherlands Government to produce more with less. The Netherlands has always had an acute phosphorus surplus due to imported feeds but now application rates are the same as harvested amounts of phosphorus. There are three classes which are regulated. If the soil is low in phosphorus, permission is granted to apply slightly more than would be harvested from the crop. If it is equal, it is the same in as out. If it is high the farmer must harvest it out. All farmers must submit results of soil analysis to a registration office. If those results are not submitted, they are automatically classed to be in high soil phosphorus levels. That is the incentive to get soil analysis done. Soil sampling is now done with GPS and the location recorded. This is to prevent farmers from taking samples from areas or fields that they know to be low in phosphorus. There is still the

possibility of those samples being taken from another field however the farmer still had to be in the correct field to record the GPS markers.

In regards to reducing phosphorus levels, from 1985 there were maximum manure production levels that were transferred into pig production rights and poultry production rights. For dairy farmers it was the milk quota system. In 2015 the milk quota system was abolished and, as a consequence, Dutch dairy farmers accelerated milk production to new levels. Now there are phosphate production rights for dairy farmers to adhere to. They are based on 2015 production levels. There is also a ceiling in total phosphorus in manure that may be produced. That ceiling is currently being exceeded by the dairy sector.

The European Commission puts the ceiling in place, with their Nitrates Directive, which deals with protecting service waters and ground water to minimize pollution of water with nitrates. Farmers are not allowed to apply more than 170kg of nitrogen per hectare from animal manure. Chemical fertiliser may be used to top it up which is uniform across Europe. Derogation allows more manure than is permissible if requested. If there is a request for derogation, there is a need to be able to justify that the application of more animal manure will not pollute the groundwater or the service waters. The Netherlands has that derogation and is allowed 250kg of nitrogen from animal manure. The EU monitors the progress of countries with derogations every four years. There are limitations as to how much manure can be produced and the Netherlands exceed those phosphorus rights level by 8-10%.

Farmers will be required to reduce these levels. This means that manure has to be physically exported to another farm or to another country.

## **Seges, Denmark**

The Danish Agriculture & Food Council owns SEGES, which is the research and innovation centre for the Danish Agricultural Advisory Service.

According to Torkild Birkmose of SEGES, except for organic cows, all cows and calves are housed indoors. It is rare the conventional farmers take their cows outside. They find it too hard to manage. It's a requirement for organic farmers to have their cows outside for a minimum of 120 days.

Manure is a very important part of the fertiliser plan for the farmers particularly in regards to phosphorus and potassium. Most farmers top up with nitrogen especially dairy farmers, as most of their grass is clover consequently there isn't a great need for additional nitrogen.

Denmark has very strict regulations in regards to adding nitrogen. There are standards for each crop as to how much nitrogen can be applied. Manure and a small amount of mineral fertiliser is applied only. If manure isn't utilised well farmers are not allowed to buy extra mineral fertiliser.

The farmers must keep count on the nitrogen, they're keen on utilising it efficiently otherwise the crops will starve of nitrogen and lose yield. Over the last 30 years a lot of research and development to improve the utilisation of manure has transpired. One important issue is to avoid ammonium evaporation. Over the years there have been many strategies that have improved or reduced the ammonia evaporation and raised the utilization of nitrogen in manure. One example is injection, where there is a small exposure to the atmosphere. Injection is a very efficient method. Another method is the trailing hoses (30cm apart). Its surface area is much greater than injection.

Splash plate application of slurry has been banned for about 15 years because the ammonium evaporation is too high as slurry is spread everywhere. The government aimed to reduce ammonium evaporation from Danish agriculture. As very few farmers were using splash plates, there was minimal impact when splash plates were banned.

75% of manure is applied by trailing hoses. The booms are from 24 meters to 36 meters wide. Injection is up to 12 meters wide. The issue with injectors is that when there is 12 meters versus 24 or 36 meters too many tracks occur in the grasses. Most grasses are clover and don't react well to 50 tonnes of drag hoses and huge tractors (350hp) compacting the soil. Another problem is when cut with the discs there is damage to the roots of the clover. Trailing hoses avoid these concerns.

The Danish government saw the need to further reduce ammonia emissions and legislated to ban trailing hoses. Using the injectors as an alternative, the ammonia emission losses could be reduced by 50%. The government decided that the trade-off between the extra costs and the reduction in ammonia was fair.

## **Fonterra, Hamilton, NZ**

According to Nuala Platt, the Sustainability Manager of Fonterra, when Fonterra first started, they were only investigating effluent as an environmental assessment on farm. It tagged onto the food safety audit so farmers could understand that Fonterra were coming out to have a look at their system and they would be questioned about it. Initially there were about 25 questions on effluent management on farm that looked at the catchment area right around the dairy to where the effluent was being spread on the land. They were also looking at discharge to water and the ceiling standards for storage facility.

It was quite intense and a big change for these farmers. Lots of questions from farmers on; "What are you doing? Why are you asking me about effluent?" It helped them set up a triage system based on the ratings that farmers got on the day of their assessment.

Regional councils are quite tough around discharge of effluent as it needs to be managed very closely. The Dairy industry was receiving much public criticism in particular from the media. This was the catalyst for Fonterra getting involved in this area.

Originally the role was the farmer phone in for advice. This changed to Fonterra being the initiator; “I’m ringing because I have a problem.” The first couple of years were a bit tougher but farmers are now saying “I’ve got a problem can you help me?”

It started with effluent but has expanded. If an issue arose with the disposal of effluent after a shed assessment the sustainability team contacted the farmer to discuss the problem and how it can be fixed. They then ask; “Can they come and visit on farm?”

One-on-one support and advice on farm is the key part to creating change. It’s about understanding how legislation works including the terms and conditions of the milk supply agreement. Ultimately, Fonterra can wave the big stick and threaten not to collect milk. A situation they’re very reluctant to do. In most instances farmers recognise they have a problem and approach them first. It’s about making sure the farmers are compliant with regulations, so they don’t get prosecutions.

So, the one-on-one advice and set plans with the farmer coupled with time frames and some work can attract high capital costs (\$100,000+). The options on the works are explained and informed of other farms to visit that have implemented changes.

Accredited system designers are suggested as an information source in the development of a new system. Dairy NZ has led a lot of the work in the accreditation of the system designers. One-on-one and creditable independent advice is key to farmer acceptance and implementation. Future planning is an extremely important aspect of system design.

Regional councils have a big influence on regulations. Regulations vary between regions. An overseer software application is used to measure the leaching of nitrogen from soils. This will form the basis of how much manure and N can be applied. Farmers have to comply and be ahead of the game.

Record keeping by farmers on forages and supplements fed to cows is critical. There is a requirement to keep feed receipts. There is an overlap of environmental and food safety in this area. No incentives were made available to farmers other than technological support to change management practices.

Fonterra is increasingly being quizzed by lawyers and banks during the negotiation phase for the sale of farms. They are more conscious of the effluent system and regularly asked; “Is there any works still required?”

Statistics from Fonterra suggest that regulation non-compliance by farmers is trending downward. Further, when profitability of the dairy industry drops maintenance on effluent systems follow suit.

Some of the more complex regulations around food safety, environmental issues and animal welfare will push some farmers out as the record keeping is becoming more onerous each year. Enterprising software businesses have expanded into the agricultural market with various farming apps to simplify data entry, provide comprehensive analysis and ensure record keeping more efficient.

# Chapter 3: Nutrient Management

## Practical Responses to Nutrient Management

### Netherlands

According to Jos van den Langenberg of Kamplan BV, the Netherlands are exceeding their European Commission phosphorus agricultural levels by 8-10%. Phosphorus remains in the manure and in the soil with some small leakages but not as much as nitrogen. Almost 25% of manure phosphorus is exported to other countries. This places Dutch farmers at a competitive disadvantage. The value of a cubic metre of cattle slurry is about €12 in terms of organic matter, nitrogen, phosphorus and potassium. They don't receive €12 but have to pay about €20 per cubic metre to export it to other farmers or countries through companies that have the appropriate equipment. The cost per dairy cow to export manure is €400 - €500. Intensive dairy farm operations will be exporting up to 50-70%. Friesland Campina is now promoting anaerobic digestion, in an effort to combat climate change. This does not help to dispose of the surplus phosphorus, as those levels don't change. The simplest way is to separate the solids and liquid. The solids will contain most of the phosphorus. The liquid contains most of the nitrogen and all of the potassium. The solid part is then exported. Unprocessed manure (solids and liquids combined) can be transported 100-150kms from the source farm before the costs become too high. Farmers will not pay more than €20 - €25 per cubic metre for the transporting of manure. To transport any further the solid fraction needs to be separated. The separated solids are 30% dry matter. This makes it cost effective to transport up to 300km. To transport it further, it needs to dry to 90% dry matter, where it can then travel 800km before costs become prohibitive. Liquids generally go to Germany, separated manure to France and the dried manure to Hungary and Poland. Poultry manure is quite dry so it is transported longer distances. Manure that is exported across country borders goes to areas where there is limited animal production and higher levels of arable farming. This is attractive for those crop producers, as they have to pay less for fertiliser. Dutch farmers pay contractors €2.5 to apply slurry to the land via soil injection. Contractors are competing against each other for work therefore keeping costs down. This also sees equipment getting bigger thus creating another concern of soil compaction.

### Kamplan B.V., Netherlands

The Netherlands have had manure problems for many years. There are a lot of pigs and dairy cows. They have too much manure for their land area. All farms in the Netherlands are working with liquid manure as animals are housed. Once or twice a year it is sucked from the pits and spread over the fields. This is allowed from February to September. There has been too much manure on the fields in the past. Water quality has deteriorated. Government

regulations only allow for the replacement of nutrients that are taken out by plants. They are obligated to treat the manure.

Farmers are initially treating the manure on site. Liquid manure is approximately 7% DM. The liquid and the DM are separated. The sticky part (DM) is taken by truck to other countries that use the phosphorus. It's important to extract as much water as possible to reduce haulage costs. It's transported 200-300km mainly to France and Germany. There are fewer animals in these countries and they can utilise those minerals in the manure. The farmer is left with the liquid which is now too expensive to transport. The liquid is treated due to the remaining nutrients. 80% of nitrogen is in the liquid and nitrogen can only be removed through biological treatment. A typical treatment plant will be a building housing two large 1000m<sup>3</sup> pits and the necessary equipment.



**Figure 3:** Nitrification – compressed air is blown through the liquid. This process converts the ammonia or ammonium to nitrite.



**Figure 3:** Denitrification – results in the reduction of the nitrates to nitrogen gas.

The liquid goes to storage and is agitated. Compressed air is blown in through a series of round rubber plates with many small holes creating fine air through the liquid. The air stream entering is very thin. The oxygen and bacteria inside the manure is being converted to nitrates. In the second stage, all the bacteria transform the nitrate to air (ammonium to air). The two stages are nitrification and denitrification. This explains the two pits, one with oxygen and the other without. A 75kw blower pumps air in. There is still some sludge. A further process is needed to separate the remaining sludge from the biological process. At the end of the process, you end up with yellow water with no nutrients. The yellowness of the water is caused by humic. There is no harm on the environment, it can be spread in large quantities and there are no traces of nitrogen, phosphorus, or potassium. The pH level of the liquid is 7.

- During the separation process, polymer and iron chloride are added to aid separation
- 80% of the nitrogen in pig manure is in the liquid. This kind of system has been in use in Belgium for approximately ten years. The Belgian government enforced it as a regulation ten years ago. The Dutch government only regulated two years ago.

- 1000 sows yield 7000 m<sup>3</sup> of manure x €22/m<sup>3</sup> = €154 000 cost to dispose of the manure. At present this system won't reduce the farmer's cost but it gives certainty to the disposal of the manure. All manure has to be transported by an intermediary. If it can't be taken, then it creates many issues on the farm. People are investing in manure treatment along with having to comply with government regulations that require it to be treated. Dairies are having trouble with the amount of manure they are producing compared with the land available for it to be spread across. There are 12 million pigs in the Netherlands with 70-80% located in the south. The biologically treated water still has to be disposed of but as there are no nutrients in it there is still requirement to transport it, but it doesn't need to go as far. Pig farms are generally on very small holdings. The farmers are allowed to spread 30 cubic metres to one hectare.
- There is scope for the water (minus the nitrogen) to be integrated into the current housing system to reduce ammonia and dust. This will reduce the need or size of air washers in piggeries. To treat the manure initially it costs €15 – €20 / m<sup>3</sup>. There is still the cost of sending it abroad. Currently it costs Dutch pig producers €22 / m<sup>3</sup> to export. (Jos van den Langenberg, Kamplan BV)

## **United Kingdom**

### **Jordanstan Hall, Pembrokeshire**

According to Mansel Raymond, most dairy farmers spread their slurry out onto the grasslands with a splash plate in the winter months. It will only be hauled short distances. Only solids are hauled vast distances. Slurry is injected during the summer months when the cows are grazing; the injection will follow the cows around. It's not about net financial benefit. Farmers have the effluent, which is regulated, and they need to do something with it. It cannot be left to sit in a lagoon or let run into a waterway. There are nutrients obviously in the slurry but with the cost of spreading it is cost neutral. Farmers will use the cheapest option to disperse effluent. Until the 1970's effluent disposal was running it into the nearest waterway. Farms were generally smaller. From the late 1970s a steady tightening of environmental regulations commenced. Farmers had to adjust and invest to make the best use of what they have. As technology moves forward there is potential for slurry to be used in anaerobic digestion plants on a cost-effective basis.

## **USA**

### **Cattle Empire – Very Large CAFO, Kansas, USA**

According to Andi Curtiss, the Regulatory Compliance Officer of Cattle Empire, wastewater from the ponds is nutrient tested twice a year. The nutrient values tend to fluctuate between spring and fall. During winter additional rains and drainage increase the amount of



waste water. There are 1,300 acres on which any wastewater can be applied. Typically, it will depend on where the nutrient values are in the soil of a specific field on what is planted and the quantity of wastewater to be applied. The Nutrient Management Plan makes them look at the nutrient value of the waste water, as well as, the nutrient values in the soils and from there calculate the quantities at agronomic rates. Commercial fertiliser can be applied if needed but not much is necessary. The phosphorus and nitrogen levels are constant between the beef and Holstein steers waste water ponds. Generally, a mix of 50:50 wastewater and well water is applied to crops. It's generally not pure waste water unless there is a need to empty ponds.

In the case of severe storm events where there is potential for overflow from ponds, Cattle Empire liaises directly with the District Office (State Authority) and work through the best way of disposing of the wastewater. Typically, the regulator will require the farmer to start all the irrigation pivots and will want the farmer to pump out so they are not discharging from a single point but over a larger area with the hope that it will stay on that ground.

### **Ohio State Extension Environmental and Manure Management, Ohio**

In the State of Ohio, they have a good livestock population. It's not as dense as some states. It's estimated that there is 2.5 billion gallons (9.46 billion litres) of dairy manure (mostly liquid) and 1 billion gallons (3.8 billion litres) of swine manure handled in a year. In total, there are 3.5 billion gallons (13.25 billion litres) which has to be spread or moved.

Approximately half the manure is applied during October, November and December. It's called fall applied manure after the crop harvest. Basically, it's wasted, the phosphorous and potash will bind to the soil and generally stay put but the nitrogen primarily is lost from when its applied in the fall to the crop season in the following spring. The majority of the research emphasises applying the manure during the growing season. Ten years ago, they started applying swine manure to wheat with the following results.

<b>FIELD DAY SURVEYS OF MANURE APPLICATION TIMING IN WESTERN OHIO</b>	
January – March	3%
April – June	19%
July – September	29%
October – December	49%

**Figure 4:** Manure application timing in Western Ohio, taken from Field Day surveys of farmers.  
Source: Glen Arnold, Ohio State University Extension Environmental and Manure Management.

According to Associate Professor Glen Arnold of the Ohio State University Extension, research has found that cover crops don't do very much for dissolved phosphorus. When most people look at manure they consider the nitrogen (N), Phosphorus (P) and Potassium

(K). In swine manure the Nitrogen portion is worth 40% of the total NPK value. Dairy manure is much lower in Ammonium Nitrogen compared to hog manure. Dairies however produce a lot of manure. Monitors have been placed on dairies in North West Ohio, milking three times a day, on average they extract 27 gallons of water from the ground per day, add in the water from feedstuff, rainfall, run-off and silage leachate most large herds have to move 30 gallons of waste water /cow/ day. Hogs are more like one gallon/hog per day. So, whilst dairy might be lower in nutrients they have greater volumes.

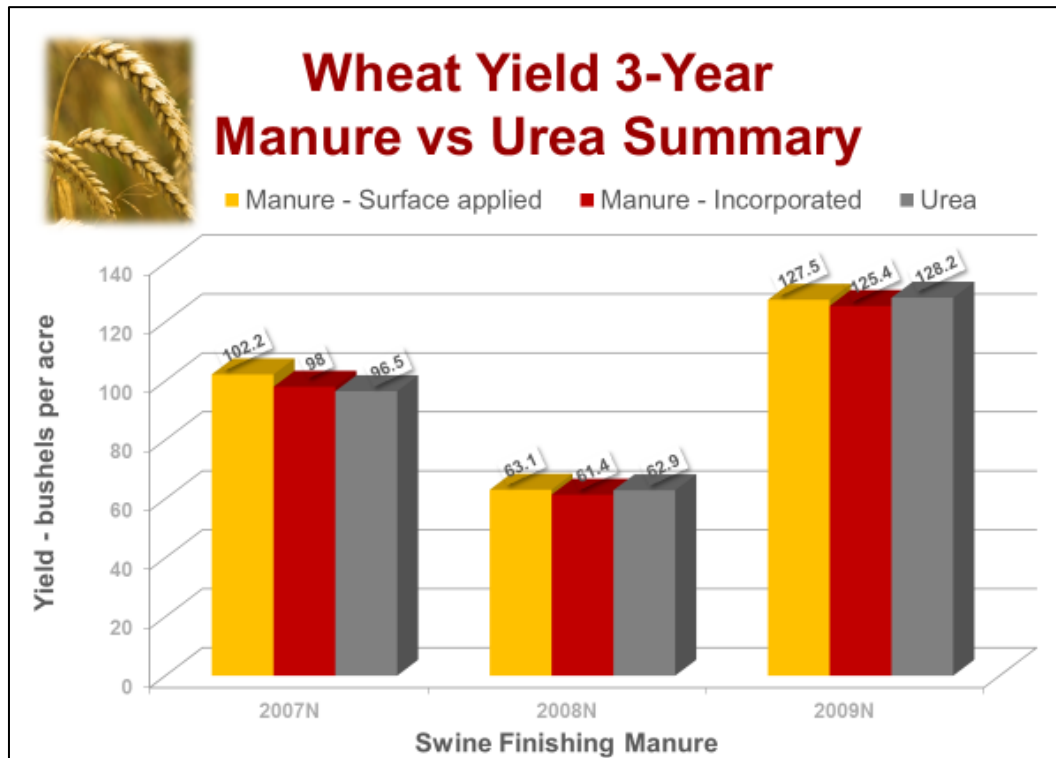
In an early trial, a drag hose/dragline system applying swine manure was used directly on 1 April to top-dress soft red winter wheat (planted in October). Contrast this with the normal practice for a farmer who would use urea or another nitrogen fertiliser which would cost about \$50/acre for the nitrogen. The farmer is spreading about 4,000 gallons/acre of manure on the wheat and the fertilisation is complete.

Odour from this is generally not an issue, as most people don't have their windows open or sitting outside on the porch in Ohio. Daytime temperature is around 65F (18C) and night time is about 40F (4C), people generally aren't outside or driving with the car windows down.

Research (Source: Glen Arnold) has been done where the manure has been knifed in, using a straight coulter making a knife mark about 10-15cm deep and 3-4mm wide with a boot of manure straight over the top. It doesn't truly get incorporated, but the majority of the manure runs down the knife cut and has worked well.



**Figure 5:** Manure being knifed in with a PEECON toolbar. Essentially it puts a slice in the field and the manure on top and compared it with surface applied urea as it has traditionally been done. The results were 95 bushels with the knifed in manure compared with 88 bushels for surfaced applied urea. Source:



**Figure 6:** A three-year study shows that there is negligible difference between surface applied swine manure, incorporated swine manure and urea. Source: Glen Arnold, Ohio State University Extension, Glen Arnold

### 2011-2015 OARDC Manure Sidedress Corn Research

Source: Arnold, G.		Yield, bushels per acre				
PRE-EMERGENT TREATMENTS	2011	2012	2013	2014	2015	5-Year Average
Incorporated 28% UAN	138.1	111.5	184.6	145.1	130.8	142.0
Incorporated swine manure	191.9	128.6	191.8	146.5	161.9	164.1
Surface-applied swine manure	180.9	109.5	175.7	137.2	110.3	142.7
Incorporated dairy manure +28% UAN	190.1	132.0	185.4	166.1	146.3	164.0
Surface-applied dairy manure +28%UAN	184.5	97.0	166.0	141.9	106.4	139.2
4R PLACEMENT Takeaway: Injected/Incorporated = +20 bpa						
POST-EMERGENT TREATMENTS						
Incorporated 28% UAN	132.7	116.0	181.9	140.9	140.1	142.3
Incorporated swine manure	180.8	138.4	196.7	139.9	158.5	162.9
Surface-applied swine manure	178.0	116.4	188.0	115.6	114.6	142.5
Incorporated dairy manure +28%UAN	180.0	138.8	192.0	156.9	167.5	167.0
Surface-applied dairy manure +28%UAN	170.5	101.6	181.5	125.3	111.6	138.1
Zero nitrogen check	74.4	62.6	82.0	67.0	40.2	65.2

**Figure 8:** Here is a five-year average, 2011,12,13,14 & 2015. The top half of the table is a pre-emergent plot. If the corn was planted on a Monday, by Wednesday the farmer would apply manure. Source: Ohio State University Extension, Glen Arnold.

Consider the 28% UAN versus incorporated manure all post treatments at the V3 stage on corn essentially ended with a 20-22 bushel difference over a five year period including three years of drought. The conclusion is that it does really well.

The incorporated manure is superior because there is less loss of nitrogen. When incorporating manure the farmer is adding moisture to the soil, which remains to benefit the crop. The ammonium manure and swine manure are positively charged, the plants can use the ammonium nitrogen immediately or eventually the soil bacteria will break it down into nitrate form. Other than odour there are not many negatives about using manure. Ohio State University is engaged in further research on manure application with a drag hose.

Harrods Farms drag hose their swine manure on corn every spring. They have been doing it for three crop seasons. Each of those seasons they work with Ohio State University and have test plots in the fields. Traditionally corn is planted on 1 May, starter nitrogen is put in a row with the corn (28% UAN) when its 6 - 8 inches (150 – 200mm) high it is side dressed with 150-180 units of nitrogen. The aim is to replace the side dressed nitrogen with liquid manure. One thing always spoken about is balance. For example. rotating crops in alternate years is very common and worthwhile.

The maths behind a farmer growing 200bu corn and 60bu soybean crops would work very well with manure. We know corn needs 0.37lbs of P<sub>2</sub>O<sub>5</sub> (phosphorus) per acre from every bushel of corn removed from the field so it will take out 751bs of P<sub>2</sub>O<sub>5</sub> /acre for a two-year total of 54lbs and soybeans removes 1041bs/acre for total of 138lbs removed over two years. When the farmer applies manure on the field (6500 gallons/acre) from his hog farm and applies it on alternate years he is replacing an almost identical amount of nutrients being removed from the corn crop. As a result the farmer isn't going to increase his nutrient values in the soil test levels, which is an essential condition in some areas. (Particularly in the Lake Erie watershed region) It takes about 20lbs of P<sub>2</sub>O<sub>5</sub> to change it by 1ppm. So, the – 5lbs of P<sub>2</sub>O<sub>5</sub> and – 6lb K<sub>2</sub>O (potassium in the form of potash) are just about zero.

**Nutrient balance of manure sidedress**

Crop		P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
Corn	200 bu		
(.37) (.27)		74 lbs	54 lbs
Soybeans	60 bu		
(.80) (1.4)		48 lbs	84 lbs
Removal		122 lbs	138 lbs
6,500 gal	manure	117 lbs	143 lbs
Net nutrient gain		-5 lbs	+6 lbs

**Figure 7:** Table showing the additions of phosphorus and potassium through hog manure balance the outputs of soybeans and corn

All lot run-off and silage leachate has to be collected on a dairy farm so there is a lot of water on dairy farms that isn't high in nutrition. The nutrient boom is great for applying this waste. It is not good at crossing surface drains and is very susceptible to blowing over in windy conditions. Ten years ago, corn was planted and there were no further applications of fertiliser. Now it's about widening that window.



**Figure 8:** The Nutrient Boom traveling through standing corn while applying dairy manure.  
Source: Ohio State Extension Environmental and Manure Management

Pit and lagoon additives: Trial plots have been done with 'More than Manure', 'Instinct' and 'Guardian', (commercial manure additives) as well as, manure by itself with 28 UAN as the control. Tissue tests were done with the ear leaf. Anything from 2.9 to 3.5 is considered to have sufficient nitrogen for the crop to finish the season. The pure manure had the highest N rating of 3.49 in the ear leaf. The others were around 3.2-3.3. They may have restricted the nitrogen but not to the detriment of the crop. The very lowest was a commercial fertiliser at about 3.1. All were at sufficient levels to finish the crop. There is anecdotal evidence that none of the lagoon pit additives on the market, at the present time, provide any additional value to the manure. Almost all the university studies done on most of these products conclude that none of them do anything for them in the field.

A concern of people from non-farming backgrounds is odour generated from lagoons, particularly on large farms. There was a fear that hydrogen sulphide was going to blow off the dairy ponds and kill them in their sleep. These concerned citizens went upwind from the dairies and measured for carbon dioxide, ammonia, hydrogen sulphide and odour, which is a subjective assessment.

In the USA there are two odour labs; one at Purdue University in Indiana and the other at Iowa State University. The universities take measurements of carbon dioxide, ammonia, hydrogen sulphide and odour. The odour test is subjective. A trained panel of people sniff the collected air and then describe their reaction to the odour. This is defined as the "sniffer test". Air from the centre of a cornfield will come back with a number of about 30. From a dairy, it's about a number of 120. Collect the air from a hog farm and it will come back with a

number of about 1,500. It gives confidence they are somehow measuring the odour. Tests have been conducted on hogs, dairy and chicken farms. When standing beside a large manure pond of 6.8 million gallons (25.7 million litres), with no wind blowing the measuring devices could barely detect any ammonia or hydrogen sulphide odours. When the wind picked up three hours later the numbers shot up dramatically, so a lot of the ammonia goes in the dairy manure. String lines with baffles similar to swimming lanes in a pool would stop the wave action across the pond thus reducing the nitrogen loss in dairy manure.

If farmers can reduce the wind action on ponds a more nitrogen in liquid manure will be saved. An option to increase the nitrogen in dairy manure is to dump 6000 gallons (22700 litres) in a frac tank (nurse tank in Europe) and then add 28% UAN to bring it up to the desired levels required for side dressing corn.

## **Ireland**

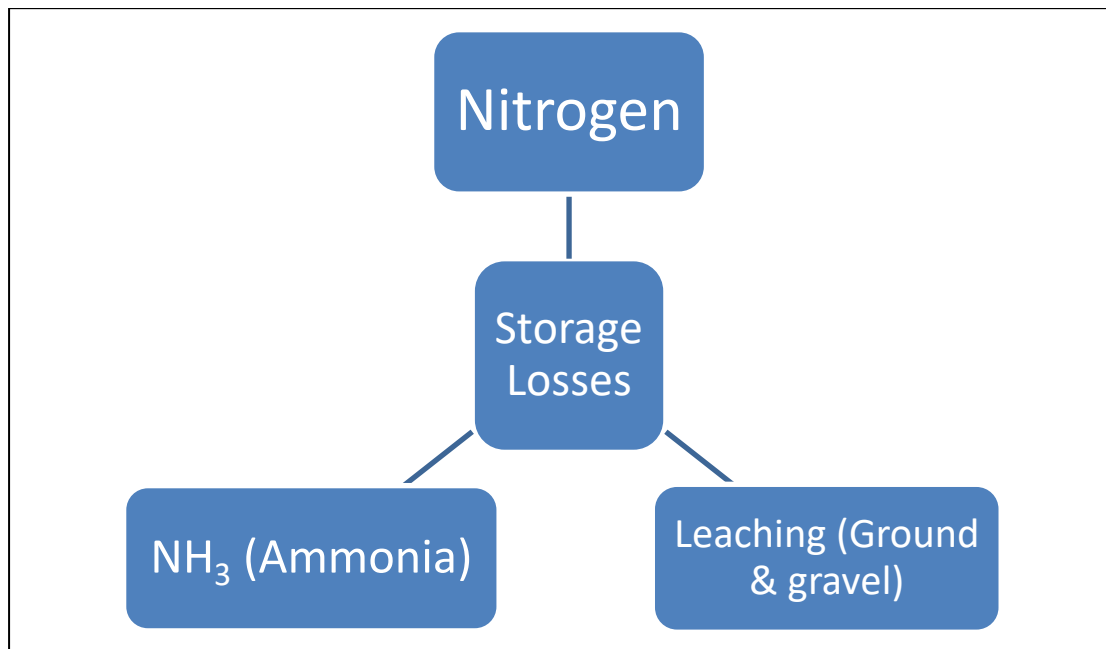
### **Grassland AGRO – Ireland**

Grassland AGRO is the second largest fertiliser supplier in Ireland. Grasslands sell about 330 000 tonnes/annum which is about 25% of the market share. (Source: Dr Stan Lalor)

According to Dr. Stan Lalor, Head of Speciality at Grassland AGRO; A cow producing 8,000 litres is excreting around 85kg of nitrogen and 13kg of phosphorus per year. If cows are doing 8,700 litres it's about 100kg nitrogen and 15kg phosphorus, multiply that by 320 equals 32000 kg of nitrogen and 15060 kg of phosphorus. That's 32 tonnes of nitrogen which is the equivalent of 100 tonnes of ammonium sulphate. On a gravel base feedpad this means a lot of nutrients are being lost. 100 tonnes of ammonium sulphate is equivalent to six tonne MAP. For every 1,000 litres of milk produced 1 kg phosphorus and 1.5 kg potassium is leaving the farm. Compare this with fertiliser maintenance rates in Ireland which are 12-15 kg/ha of phosphorus annually.

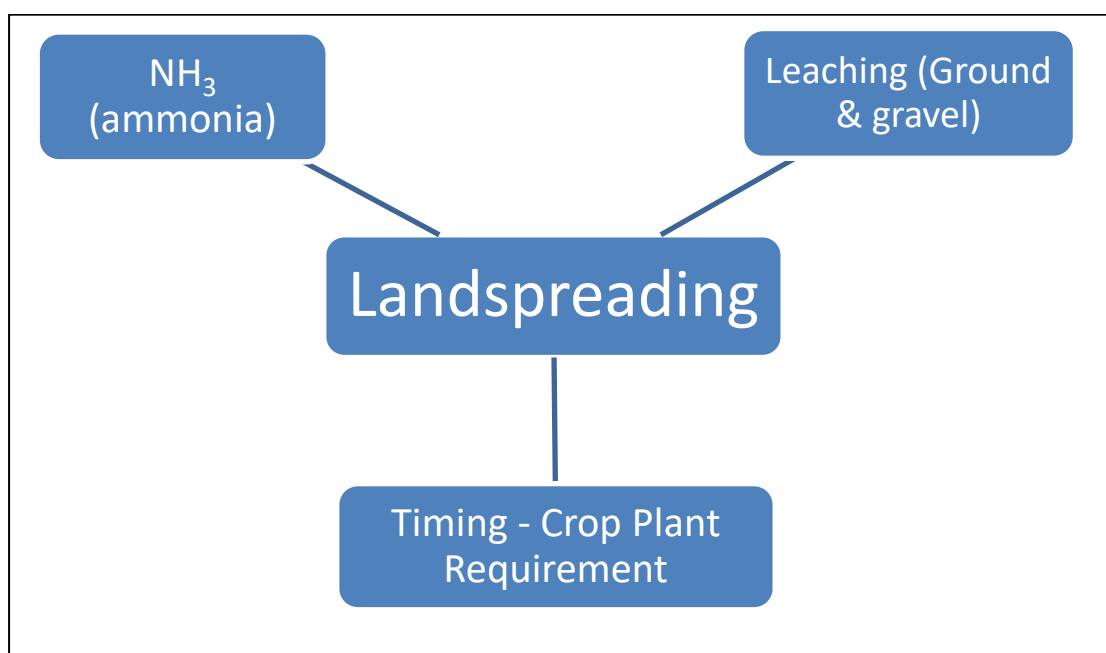
### ***Gravel base feed pad versus Cement Feedpad***

To get maximum efficiency of the manure system the farmer needs to minimize the leakage in the recycling so input costs from commercial fertilisers are lowered. Examining the manure loss pathways there is phosphorus and potassium to consider. Capturing the manure, often in places around the farm where it is not needed and then targeting it back at the fields based on their phosphorus & potassium requirements. Capturing nitrogen is a problem as there are storage losses.



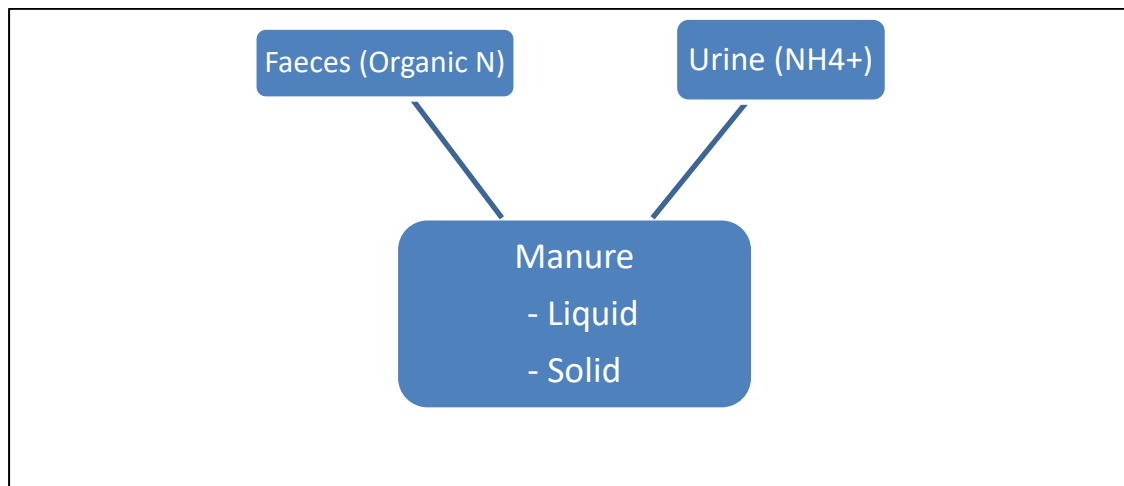
**Figure 9:** To lower costs of commercial fertilizers, the farmer needs to minimize the leakage in the recycling system and maximum efficiency of the manure system.

These losses are ammonia (NH<sub>3</sub>) and potential leaching into the ground or the gravel base of the feedpad. With land spreading there are issues; NH<sub>3</sub> losses can be significant along with leaching as well but they are both separate issues. The key to them is timing for optimum crop uptake requirement.



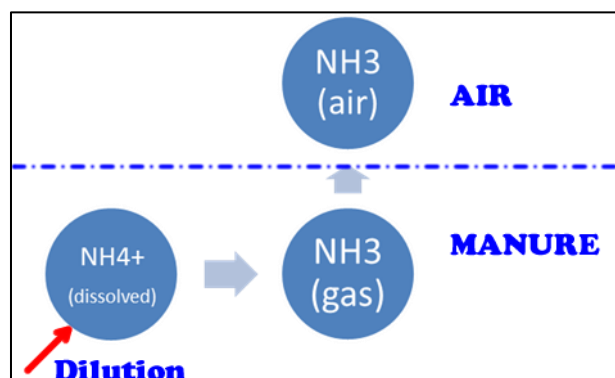
**Figure 10:** Optimizing manure management is capturing the manure and timing the spreading.

When communicating with farmers and optimizing manure management it's about "*Where and When*". With a gravel base feedpad the question is how much is being captured because with the concrete feedpad or the slatted houses. There is no loss of volume. The other thing to note about manure is the significant understanding ammonia in the manure from the urine ( $\text{NH}_4^+$ ). Urine and faeces come together to make manure. It can be liquid or solid.



**Figure 11:** Manure is liquid or solid and it is composed of faeces and urine.

Organic nitrogen is very safe and stable. It is slowly released into the soil.  $\text{NH}_4^+$  is very prone to losses in storage or during application particularly in hot dry weather. One of the big factors with a concrete feedpad is dilution. Dilution is so important because ammonium in slurry can turn to ammonia gas. The  $\text{NH}_4^+$  is dissolved and  $\text{NH}_3$  is gas within the slurry solution.



**Figure 12:** Consider an imaginary membrane between manure and air then ammonia gas ( $\text{NH}_3$ ) goes off into the air and is lost.

Dilution is the solution, the higher the concentration of ammonium the higher the likelihood of it turning to ammonia gas. As this builds up it is more likely to be lost out of the system. If diluted, the concentration of ammonia per cubic metre has more volume but the same nitrogen at a lower concentration and this helps reduce ammonia loss.



Ammonia Losses		
Dry Matter 10%	100%	10-20%
Liquid		NH3 Loss NFRV
Dry Matter 1%	5-20%	80%

**Figure 13:** Comparison of ammonia losses: A dry matter scale in liquid manure with a range of 10% down to 1%. Another way of looking at it is Nitrogen Fertiliser Replacement Value (NFRV).

In trials at Moorepark (TEAGASC) working on dirty water and Johnstown Castle (TEAGASC) on slurry that had a 7-8% dry matter content, they achieved NFRV in the range of 10-20% which meant the total nitrogen in that slurry if compared to the response expected from chemical fertiliser, every kilogram of nitrogen slurry was growing the same grass as about 10-20% that weight as nitrogen fertiliser.

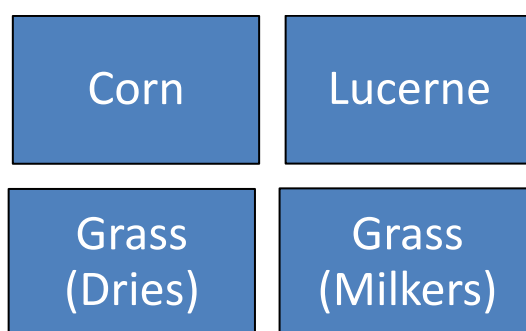
At Moorepark on dirty water and the dairy effluent they were getting NFRV's of 80%. So for every 10kg nitrogen in 8% slurry was only worth 1-2 kg in chemical fertiliser but every 10kg of nitrogen in the diluted solution was worth 8kg of nitrogen in chemical fertiliser. That is the big winner when comparing a concrete feedpad as opposed to a gravel based feedpad. The increased volume storage can be seen as a negative, but the farmer is potentially multiplying the nitrogen fertiliser value in the effluent for two reasons; the first is the farmer is preventing any leakage into the gravel or soil because they are capturing everything, and secondly the dilution that is coming from capturing all effluent improves the retention of nitrogen for land spreading.

In terms of application methods two were trialled; splash plate where everything was covered and trailing shoe where it goes out in lines. If the area exposed is reduced, ammonia loss is reduced however dilution will solve this problem. If all effluent was 1% DM then broadcasting with a splash plate would be fine. Considering shallow injection which is an extension of the trailing shoe system and also at application in April (spring) and application in June (summer), trials revealed that applications in April (spring) that the long-term fertiliser value was 30% and in June was 20%. By going from June to April 10% was added and by going from splash plate to trailing shoe 10% was added to the potential fertiliser value with an 8% DM slurry. When Moorepark used 1% slurry they achieved 80% no matter when it was applied. However, if the farmer is in a dilution system it means they have eight times more volume to spread which increases the spreading costs. The key to efficiency is matching up where on the farm nutrients are needed and getting it there.

OUTCOMES FROM APPLICATION METHODS		
8% DM	Splash plate	Trailing Shoe
April	30% + 10%	40%
June	20%	30%
April or June 1% DM	80%	80%

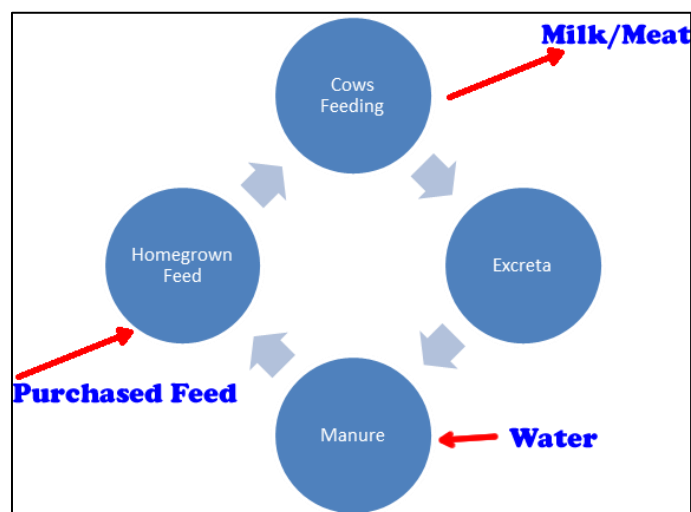
**Figure 14:** Comparison of Splash Plate vs Trailing Shoe

Lagoon additives can be useful and Grassland AGRO has measured good yield increases. It makes the slurry more biologically active. Nitrogen and Phosphorus are more available and better nitrogen retention, but they are secondary to getting the correct manure distribution on the pastures and crops correct.



**Figure 15:** Consider a farm divided into four blocks; one of corn, lucerne, grass (dry cows) and grass (milking cows). Those parcels of land depending on soil types will have different nutrient requirements.

Historically when manure had no value it was put wherever it was easiest and cheapest to place. But it is worth understanding what the removal of NPK is from the different cropping systems and these will vary substantially. The manure cycle starts with the cow feeding; some of that leaves as milk/meat, there is excreta, add that into the manure along with water. The inputs for the cow are; home grown feed and any purchased feed. The efficiency occurs and the loop is closed when the manure goes back into the home grown feed.



**Figure 18:** The manure cycle is closed when manure is employed to develop home grown feed

What is missing in a lot of systems is the link between the manure and the home-grown feed. The milk and meat are taking nutrients out of the farm, the home grown feed is bringing it in and then the fertiliser fills the gap. A very simple exercise of doing this across the different cropping systems helps to manage this cycle in a better way. The 4 x R's of nutrient management are:

**Right Type/Material:** This is applicable to fertiliser and dilution.

**Right Rate:** What is being pulled out? What needs replacing?

**Right Place:** Mainly for fertilisers

**Right Time:** Does the farmer have the storage? Does the farmer have the machinery to distribute?

One of the big changes in Ireland has been the move to slurry applications in October to applications in February and March. When slurry is spread in October it has the winter period to leach nitrogen whereas in the February/March period the grass is looking for a nitrogen hit, and the outcome is a better nutrient uptake. The right rate and right time are the most important considerations of the 4 R's in terms of manure.

The application method and additives are secondary to rate and time. With the type and material separation is another consideration. With a liquid, there is a tendency to concentrate nitrogen and potassium whereas in the solid material the tendency is to concentrate phosphorus.

Matching the ratio to the crop where it is required is important. If the farmer was to maximize his grazing crop the K:P ratio typically required in a fertiliser program would need two parts potassium and one part phosphorus. In silage the demands are around six parts potassium to one-part phosphorus. Slurry for silage production is perfectly balanced in terms of phosphorus and potassium. Slurry is a very well-balanced fertiliser for silage. (Source: Dr Stan Lalor)

Dilution, as well as, acidification is a cure for the ammonia loss. If slurry is acidified it reduces the disassociation of ammonium to ammonia. Sulphuric acid (the more popular) or nitric acid is added to slurry. Acidify slurry to drop the pH and then the ammonia emissions are reduced. Urea and slurry are nearly one of the same in terms of trying to maximise nitrogen retention. An April (spring) application is generally better than June where there is less soil radiation, more humid conditions, less conditions for drying and losing ammonia. But if at any time of the year the farmer can get manure out in front of rain they will wash the slurry in faster. If the ammonium gets contacted to soil during the rain event then cation exchange capacity soaks it up and prevents it being lost so it can then be used as fertiliser.

Composting where there is a very nice humidified material is also a very good way of losing ammonia. The heat generated in composting is burning carbon and soil will compost manure after it has been applied and the carbon losses will also be there. With solid manure the cost efficiency of haulage is much higher than liquid. This allows the transport of it further from the collection point. The nitrogen efficiency in 1% slurry is extremely efficient.

## **New Zealand**

### **Fonterra, Hamilton**

Variations in sustainability plans vary between processors. In high rainfall areas the management of effluent is extremely difficult. With it being continually wet it is hard to irrigate to land particularly when regulatory authorities don't want it discharged to waterways. Fonterra has base standards, which are uniform across the country.

For high rainfall areas where there is a need for effluent discharge, the following solutions have been offered to farmers by Fonterra:

- Extremely large storage ponds for effluent,
- Low rate irrigation (pods, K line irrigators),
- Implementation of feed pads; farmers need to understand the requirements of their local councils as there are different guidelines between regional councils. Fonterra encourage their farmers to use the solids from them as part of cropping operations.

Councils will monitor the level of nitrogen use. They are unlikely to go out and measure the amount being applied. It is usually assessed via observation of areas being greener than others. It will be a judgement call not a measurement. No more than 25ml at any one time can be applied in the Waikato area. It is recommended that about 12-15ml be applied as anything exceeding this level is being wasted.

There are issues particularly around Auckland where, through urban expansion into rural areas, there are more complaints as people are on the boundary of a dairy farm and their house is on what used to be dairy farm land. Hence there are tensions between the different expectations of the rural and the urban.

# Chapter 4: Summary of Manure Management between Countries

## United States of America

The USA is slightly different in their approach to manure management. There are vast areas under cropping and hence no shortage of farm land on which to apply effluent and manure. The requirement for a nutrient management plan is triggered by the CAFO.

Tile drainage is significant throughout the Midwest. However, this can lead to high levels of nutrient run off if not managed properly.

*“In the Midwest and other humid areas, the purpose of drainage is to remove excess water and lower the water table. This creates a well-aerated environment for roots and soil organisms. Drainage allows earlier warming of soil in the spring, and earlier traffic on fields. Installation of drainage tiles can have a rapid and large return on the capital investment, by substantially improving productivity.*

*Drainage has been part of U.S. agriculture since colonial times, but it expanded to a broad scale when Europeans settled the Midwest. At the time of settlement, large proportions of Illinois, Ohio, Indiana, Minnesota, Iowa, and Missouri were swampland unsuited to normal cultivation. Large areas in north eastern Arkansas, the gulf plains of Texas, and delta areas of Mississippi and Louisiana were also originally swamp and overflow areas.*

*“Most of the drainage of the Midwestern wetlands occurred in the early 1900's in response to federal and local government support for drainage districts and improvements in drainage technology. Despite the Depression, the federal government provided financial assistance in the 1920's and 1930's to maintain and expand drainage systems.*

*Tiling continues and with the increase in crop and land prices in the last few years, along with several wet years, that slowed planting and harvest, more tiling is being done. “Illinois has 35% of its cropland tilled. Indiana has 50%, as does Ohio, Iowa only has 25%.” (Drainage Tile History in the U.S., 2017)*

## European Union – The Netherlands, Denmark, Ireland and UK

The Netherlands and Denmark are widely considered to be at the forefront of manure management influenced by intensive farming operations and high productivity on small parcels of land. As a consequence, they develop systems which allow them to process the effluent on site and export it to areas where manure can be more effectively used. The extent of the processing is determined by the export distances.

Regulations are the driving force behind this advancement. Danish regulations are much more stringent than what is prescribed by the EU Nitrates Directive. NVZ zones (EU

regulation) are designated areas of land that drain into nitrate polluted waters, or waters which could become polluted by nitrates. NVZ areas are reviewed every four years. These EU regulations encourage consistency of regulations and practices in many countries.

Anaerobic Digestion plants are located throughout Europe. They are not economically viable unless the farmer has Renewables Obligation Certificates (ROC's).

## **Denmark**

In their immediate surroundings, farmers strive to reduce emissions of ammonia and odour by using the most advanced technology available and by following strict Danish regulations governing this area. Permits are required from the authorities before new animal production units can be built or existing units expanded. In the future, these will be situated away from environmentally vulnerable areas and operated with due consideration to possible odour impacts on neighbours.

Crop producers in Denmark have progressively substituted significant amounts of artificial fertiliser by increasing their utilisation of slurry from pig, cattle and poultry farms on arable land. Through this more natural recycling of nutrients, the loss of nitrogen from Danish crop farming to the aquatic environment since 1985 has fallen by 56%. Likewise, phosphorous losses have been reduced by 98% since 1985.

Denmark has been a frontrunner in the implementation of environmental legislation for many years. The authorities have strived to implement all EU Directives in Danish legislation and in many areas Denmark's national legislation exceeds the requirements of EU Directives. For example, Danish crop producers may only spread a maximum of 140kg of nitrogen in the form of pig slurry per hectare of land, compared to 170kg in other European countries. In contrast to EU standards, Danish farmers are also controlled by fixed limits for odour nuisance affecting neighbours and nearby residential areas.

The Danish authorities employ one of the world's strictest agricultural control systems. In the environmental area, unannounced inspections are carried out to check land use, feed mixtures, fertiliser accounts, distance to watercourses, and management of slurry and chemicals, as well as health and safety conditions. (Source: The Environment 2017)

## **New Zealand**

Regional councils which will encompass a number of District councils are the driving force behind regulations. Some sensitive areas near waterways will require "consent to farm" approval. Unique to New Zealand, milk processing company Fonterra has also been instrumental in its desire to maintain New Zealand's image as "Clean & Green", developing

guidelines and advice for their farmers. Farmers are restricted to applying 50 units of nitrogen from effluent in a 24-hour period 250 kg in a 12-month period.

Up until two years ago in New Zealand, if a farmer had a two pond storage system in place, effluent could settle in the first pond then flow in the second pond and overflow into a waterway. This can no longer occur.

## **Australia**

The Environment Protection Authority administers and enforces the Environment Protection Act 1970 as well as various regulations and policies. It is important to note that the environment protection framework in Victoria places the onus of environment protection on those that manage the land and water resources.

Farmers should be doing the following in regard to dairy effluent management in order to comply with the objectives of the Environment Protection Act and associated policies:

- All effluent from the dairy, feedpads, standoff areas, underpasses and tracks must be contained and reused (most commonly spread back on pastures and crop).
- Effluent must not enter surface waters (including billabongs, canals, springs, swamps, natural or artificial channels, lakes, lagoons, creeks and rivers).
- Runoff containing effluent must not leave the property boundary.
- Effluent must not enter ground waters either directly or through infiltration (for example seepage from ponds).
- Effluent must not contaminate land (discharging effluent onto the same small area over time will cause nutrient overload and contaminate land).
- Offensive odours must not impact beyond property boundaries.

(Management of Dairy Effluent, 2008)

# Conclusion

The current regulations that Australian farmers are expected to comply with are quite relaxed and not very onerous in comparison to other countries. This is in part due to the vast land area of the nation but also the lower fertility of the soils.

In regions where farming is more intense, farmers come under greater pressure to employ innovative operations and management strategies to be compliant with regulations and improve profitability. Farmers need to be more proactive implementing new sustainable practices based on good research or the regulators will introduce environmental rules that may not always be in the best interests of farmers. Lessons can be learned from the Blue Flag Farming Partnership in Wales where farmers are trying to develop a partnership. The focus of this partnership is self-regulation within the EU NVZ rules.

This study has shown that lessons can be learned from overseas experiences to improve practices. At small intensive farms in some EU countries, especially Denmark, they have needed to be innovative in their application, whilst the Netherlands are processing and exporting effluent and manure as fertiliser. EU regulations have been the driver of significant changes in farm management practices.

The Nutrient Management Plan used in the USA has some merit for application in Australia. It provides for:

- **Right timing of application** - greater productivity can occur if we apply nutrients at the right time and at the right rate. Nutrient uptake by plants is at its greatest when they are actively growing.
- **Right rate of application** - understanding the nutrient requirements of the crops and soils meets the needs of both without overloading with specific elements.
- **Regular soil testing** - ensures that nutrient requirements of crops can be maximised and deficiencies in soils can be identified.
- **Document applications** - provides the history and what changes are taking place.
- **Regular nutrient analysis of effluent and manure** - gives greater reliability on the nutrients being applied, particularly as farmers can then adjust the diet of the animals.

Currently, Australian farmers generally use the cheapest method to apply effluent and manure. Practices in the USA and the EU show that the application method is important. The cheapest application method has not always proven in the long-term to be the most cost effective.



When looking to maximise the nutrient value of solid manure that has accumulated from loafing areas or bed packs in housed operations, the author concludes that the best option is to apply it in the raw form directly to the land and worked into the soil.

15-20% extra of DM can be grown from the digestate treated crops as the nitrogen component is more available for plant uptake. The downside to getting digestate is the need for an anaerobic digester to help create it. Dairy effluent on its own does not generate enough gas to make it an effective and efficient energy source at present. Nearly all digesters in Europe receive some sort of subsidy to operate.

# Recommendations

1. Farmers need to treat effluent and manure as a fertilizer and not as a waste product of the farms activities.
2. Government regulations for effluent management need to reflect industry best practice that is adapted for the Australian landscape.
3. These regulations should have minimal impact on the farmer's cost of production which may affect their financial viability.
4. Farmers should be encouraged to develop and implement a Nutrient Management Plan that:
  - Meets the farming objectives relevant to their current or future operations.
  - Encourages their farming practices to meet all legislative expectations.
  - Compares nutrient inputs from all sources on the farm with all nutrient outputs.
  - Minimises the risk of damage to the environment.
5. The focus for effluent management would be more effectively implemented if a collaborative approach to nutrient management was a partnership between farmers, industry organisations and government agencies.
6. More support from Government bodies directed toward sustainable farming and the introduction of best farming practices. Farmers if left to their own devices will nearly always defer to the cheapest option which may not necessarily lead to the most appropriate environmental outcomes. Governments whether Federal, State or local need to provide incentives for farmers to improve their practices to meet changing community expectations.

# References

Adams, P. (April 2017) Farmer, Adams Organic Dairy, Wisconsin, USA. (J Keely, Interviewer)

ADAS Services, 2017, ADAS UK, viewed June 2017, <http://www.adas.ukservice/farmscoper>

Agriculture: Nutrient Management Plan, United States Environmental Protection Agency, Viewed, June 2017, <https://www.epa.gov/agriculture/agriculture-nutrient-management-and-fertiliser>

Arnold, G. (August 2016) Associate Professor, Ohio State Extension Environmental & Manure Management, Ohio, USA. (J Keely, Interviewer)

Bell, J., Casey, K., Heflin, K., (April 2017) Researchers, Texas A & M AgriLife Research & Extension Centre, Texas, USA. (J Keely, Interviewer)

Birkmose, T. (October 2016) Land Consultant Seges, Aarhus, Denmark. (J Keely, Interviewer)

Brown, Roy. N, In the Heart of the Beef Feeding Empire, viewed June 2017, <http://www.cattle-empire.net/>

Certification Certificate, Natures International Certification Services, viewed, June 2017, <http://www.naturesinternational.com/certificates/WI0119-GL-11-1245.pdf>

Connelly, B. (April 2017) University of Wisconsin Falls, Wisconsin, USA. (J Keely, Interviewer)

Curtis, A. (April 2017) Regulatory Compliance Director, Cattle Empire, Kansas, USA. (J Keely, Interviewer)

Drainage Tile History in the U.S. 2017, University of Illinois Board of Trustees, viewed June 2017, <http://web.extension.illinois.edu/bioreactors/history.cfm>

Dairy Australia, 2017, Viewed June 2017, <http://www.dairyaustralia.com.au/Industry-information/>

Effluent and Manure Management Database for the Australian Dairy Industry, Dairy Australia, viewed January 2017, <http://www.dairyingfortomorrow.com.au/tools-and-guidelines>

Greenberg, J. (April 2017) Farmer, Greenberg Farms, Wisconsin, USA. (J Keely, Interviewer)

Kalita, P.K., Cooke, R.A.C., et al, 'Subsurface Drainage and Water Quality: The Illinois Experience' Transactions of the ASABE. Vo. 50(5): 1651-1656.

Lalor, Dr S. (September 2017) Head of Speciality, Grassland AGRO, Ireland. (J Keely, Interviewer)

Langenberg, Jos van den. (October 2016) Kamplan B. V., Netherlands. (J Keely, Interviewer)

Management of Dairy Effluent, 2008, Australian Dairy Farmers, viewed June 2017, <http://www.epa.vic.gov.au/business-and-industry/guidelines/water-guidance/~media/Files/water/docs/2008-DairyGains-Victorian-Guidelines.pdf>

NPDES Permit Writers' Manual for CAFOs, viewed June 2017, [https://www3.epa.gov/npdes/pubs/cafo\\_permitmanual\\_chapter5.pdf](https://www3.epa.gov/npdes/pubs/cafo_permitmanual_chapter5.pdf)

Nutrient management: Nitrate Vulnerable Zones, Department for Environment, Food & Rural Affairs and Environment, Feb 2017, <https://www.gov.uk/guidance/nutrient-management-nitrate-vulnerable-zones/>

Nutrient Management Plan 2005, Environmental Protection Authority, viewed January 2017, <http://www.oda.state.ok.us/aems/nmp-epa.pdf>

Nutrient Management Annual Updates 2016, State of Wisconsin, Department of Agriculture, Trade and Consumer Protection, viewed June 2017, [https://datcp.wi.gov/Pages/Programs\\_Services/NMUpdates.aspx](https://datcp.wi.gov/Pages/Programs_Services/NMUpdates.aspx)

Oenema, Professor, O. (October 2016) Wageningen University, Netherlands. (J Keely, Interviewer)

Platt, N. (January 2017) Sustainability Manager Fonterra, Hamilton, NZ. (J Keely, Interviewer)

Pritchard, W. (June 2017) Blue Flag Farming Partnership, Pembrokeshire, UK. (J Keely, Interviewer)

Raymond, M. (September 2016) Farmer, Jordanstan Hall Farm, Pembrokeshire, UK. (J Keely, Interviewer)

The Environment 2017, Danish Agriculture & Food Council, viewed June 2017, <http://www.agricultureandfood.dk/danish-agriculture-and-food/environment>

Wall, D. (September 2017) Teagasc, Agriculture and Food Development Authority, Moorpark, Ireland. (J Keely, Interviewer)

Wines, M 2014, 'Behind Toledo's Water Crisis, A Long Troubled Lake Erie', The New York Times, 4 August 2014, <https://www.nytimes.com/2014/08/05/us/lifting-ban-toledo-says-its-water-is-safe-to-drink-again.html>

John F Keely

# Plain English Compendium Summary

Project Title: Farm Effluent Management	
Nuffield Australia	
Project No.:	1618
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Objectives	To investigate international practices and identify key methods which can better utilize the nutrients from manure and effluent, to improve management practices and share these with colleagues.
Background	The dairy industry particularly in irrigation areas is becoming more intensified. Varying management systems has seen vast amounts of manure quickly build up in a small area. Applying this manure directly to pastures in its raw form presents a number of problems including weed control, leaching of nutrients into water courses and the degradation of our soils.
Research	The author visited the UK, Ireland, Denmark, Netherlands, USA, New Zealand, Belgium, Germany and Canada. On these trips he met with and interviewed farmers, regulators, researchers from industry and universities, as well, as observing on a variety of farms the direct impact of their use of effluent and manure.
Outcomes	The effective use of manure and effluent can be used to complement a biological farming system by improving soil health and structure, reducing costs and improving profitability. Farmers, large and small are being challenged on all fronts to improve their stewardship of their land and ensure their practices do not negatively impact on their environment. Many agricultural businesses and research centres are heavily involved in research to make better use of farmer resources and we need to continually monitor their research.
Implications	The entire chain in the dairy industry need to assume responsibility for improvements so we all become better resource managers and environmental stewards.
Publications	Verbal presentation, Nuffield Australia National Conference, Darwin, 2017.