Teagasc National Farm Survey

A Report on Bovine Manure Management, Application and Storage Practices in Ireland

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Context

Due to the importance of manure management from a national emission inventories' perspective, as well as from a Nitrates' Directive standpoint, the Teagasc National Farm Survey has been adapted over the last number of years to collect a wider suite of management data in this area (Buckley et al., 2019). This report presents data relating to bovine animal housing periods, slurry and farm yard manure (FYM) storage, manure generated by different animal types, season of manure application and application methods and manures stored by different type of storage method. Results are presented at an aggregate level and on a national, nitrate zone and farm system basis over the 2016 to 2018 period. **No data is available on sheep housing periods, so data presented in this report relates exclusively to bovine generated animal manure**

National Aggregate Results

- **Housing of dairy cows and bulls:** Dairy cows and bulls were housed for 121 days on average over the 2016-2018 period. Other livestock categories tend to be housed for between 147-150 days.
- **Storage of manure:** 81% of manure was stored as slurry and 19% as FYM on average over the study period. Slurry / FYM storage ratios ranged from 94%/6% for dairy cows to 56%/44% for cattle 0 to 1 years respectively.
- **Source of total slurry:** 30% of aggregate slurry generated (and stored) nationally was derived from dairy cows, 25% from suckler cows and 11-14% from each of the cattle 0 to 1 years and cattle 1 to 2 year age categories. Cattle categories over 2 years of age accounted for between 1-3% of aggregate slurry.
- **Source of total FYM:** 46% of aggregate FYM generated came from the cattle 0 to 1 year age category, suckler cows were responsible for a further 22%. With the remaining animal categories accounting for between 1-10% of the remaining aggregate FYM.
- **Timing of slurry application:** 44% of slurry was applied to land between January and April, a further 40%, 13% and 3% was applied between May-July, August-September, October-December, respectively.
- **Timing of FYM application:** 44% of average aggregate FYM was applied in August-September, with a further 36% applied in October-December.
- **Method of slurry application:** 84% of slurry was on average applied via the splash plate method, 10% was applied via an umbilical systems, 3% was accounted for by LESS and 1% was applied via injection.
- **Type of slurry storage:** 87% of aggregate slurry on average was stored under a roofed slatted tank, a further 5% was stored in an unroofed underground tank and 4% was stored in both uncovered over ground tanks and covered over ground tanks. Lined lagoons account for 1% of aggregate slurry stored over the study period on average.

Nitrate Zone

Under nitrates based regulations, Ireland is divided into three geographic zones. Southern and eastern counties are in zone A, south-western and western counties are in zone B and some of the counties bordering Northern Ireland make up zone C. Summary results outlined below hence relate to these various zones.

- **Duration of slurry storage period:** Farms in nitrate zone A had the shortest animal housing period on average over the study period.
- **Storage of Slurry:** 74%, 89% and 91% of aggregate animal manure was stored as slurry in nitrate zone A, B, and C respectively.
- **Storage of FYM:** 26%, 11% and 9% of animal manure was stored as FYM in nitrate zone A, B, and C respectively. A higher ratio of FYM storage (versus slurry) were associated with cattle 0 to 1 years.
- **Source of Slurry:** 40% of slurry generated and stored in nitrate zone A was derived from dairy cows. While a total of 31% and 37% of slurry generated in nitrate zones B and C was derived from suckler cows.
- **Source of FYM:** Between 45-54% of FYM generated and stored across all 3 nitrate zones was associated with the cattle 0-1 year category over the 2016-2018 period.
- **Timing of slurry application:** The majority of slurry applied in nitrate zones A and C was applied between January-April at 45% and 43% respectively, whereas 46% was applied between May and July in nitrate zone B.
- **Timing of FYM application:** The majority of FYM was applied between August-September in zone A (47%) and zone C (49%). Whereas, the majority in zone B was applied between October-December (47%).
- **Method of slurry application:** 91% of slurry was applied via splashplate in nitrate zone A, this declined to 83% and 63% for nitrate zones B and C respectively. Slurry application by an umbilical system accounted for 5%, 13% and 25% in nitrate zone A, B and C respectively. Low emissions slurry spreading accounted for between 2-4% of slurry applications across the zones.
- **Type of bovine slurry storage:** Between 87-95% of slurry was stored under a roofed slatted tank across all nitrate zones on average.

Farm System

No data is available of sheep housing periods, so data presented in this report relates exclusively to bovine generated animal manure. However, sheep and tillage farms are included in this analysis as many have bovine animals. Summary result below hence relate to bovine slurry across various farm systems.

- **Storage of manure:** 81-83% of bovine based animal manure was stored in slurry form on dairy, cattle and sheep farms. Except for the cattle 0-1 year category, the majority of manure generated by other animal categories was stored as slurry on dairy, cattle and sheep farms.
- **Source of slurry:** 77% of total slurry on dairy farms was generated by dairy cows. The majority of bovine slurry (41-47%) on cattle and sheep farms (with cattle) was generated by suckler cows.
- **Source of FYM:** 66% of FYM generated on dairy farms was associated with cattle 0-1 years with a further 26% generated by dairy cows. On cattle and sheep farms (with cattle), cattle 0-1 year and the suckler cow categories generally accounted for the majority of FYM.
- **Timing of slurry application:** Tillage farms with bovine slurry tended to apply the most proportionately in the January-April period at 58% of total slurry. This was followed by dairy (46%), sheep farms with cattle (43%) and cattle farms (41%). Cattle and sheep farms tended to apply greater proportions in the May-June period (45% on average) compared to dairy (36%) and tillage farms (24%).
- **Timing of FYM application:** The majority of FYM tended to be applied in or after August (greater than 70%) across all farm systems
- **Method of slurry application:** Over 90% of bovine slurry applied on cattle, sheep and tillage farms on average was by the splash plate method, this declined to 75% for dairy farms. Slurry application by umbilical systems was more prevalent on dairy farms, accounting for 17% of total slurry applied on an average aggregate basis.
- **Type of slurry storage:** Over 97% of bovine manure that is stored as slurry is stored under a roofed slatted tank across cattle, sheep and tillage farm systems. However, the figure was lower for dairy farms (79% on average).

1 INTRODUCTION

Manure management is responsible for 10% of Irish greenhouse gas emissions (Duffy et al., 2020). Methane is emitted during the anaerobic decomposition of organic matter during manure storage, especially in liquid manure (slurry), while nitrous oxide (N_2O) is emitted via the nitrification of NH_4^+ and partial denitrification of NO_3 during storage of solid manure and soil application of both solid and liquid manures (Kavanagh et al., 2019). Additionally, ammonia (NH_3) volatilisation is a major loss pathway for nitrogen, agriculture accounts for approximately 99% of national ammonia emissions in Ireland, of which 90% are associated with the management of livestock manure (EPA, 2019). The majority of NH_3 emissions originate from livestock manure streams such as housing, storage and land spreading of manures (Burchill et al., 2017).

National inventory based estimation of greenhouse gases and air pollutants are established from activity data multiplied by an emission factor. This report increases the detail available for national level activity data in the areas of animal housing days, proportions of manure stored as slurry and farm yard manure (FYM), manure generation by different animal types, manure applications during different seasons and by different application methods as well as proportion of manure stored by type of storage method. All of the data presented are relevant for the more accurate estimation of national level GHG and air pollutant inventories.

In addition to gaseous emissions, the activity data contained in this report may assist policymakers in the area of water quality. The EU Nitrates Directive (91/676/EEC) was introduced in 1991, with the objective of reducing water pollution caused or induced by nitrates from agriculture and preventing further such pollution, with the primary emphasis being on the management of livestock manures and other fertilisers. In Ireland the Nitrates Directive has been implemented through the Good Agricultural Practice regulations (Government of Ireland, 2006; 2009; 2010; 2014; 2017; 2018; 2020). Indeed, the most recent iteration of these regulations (Government of Ireland, 2020) requires farmers who are farming under a Nitrates Derogation to use Low Emission Slurry Spreading (LESS) equipment for all slurry applied after 15th April in 2020 and all slurry spread post 12th January in 2021.

Given the importance of manure management in the context of gaseous emissions and water quality, the Teagasc NFS has been adapted over the last number of years to collect a wider suite of environmental/sustainability data. While not directly comparable (due to differences in methodologies) this report follows on from previous reports in the area from Hyde et al. (2008) and Hennessy et al. (2011).

2 MATERIALS AND METHODS

2.1 DATA

The data used for this analysis has been extracted from the Teagasc NFS. The NFS has been produced annually since 1972 and fulfils Ireland's statutory obligation to provide data on farm output, costs and income to the European Commission through the Farm Accountancy Data Network of the European Union (FADN). Over time, there has been an increased appreciation that data relating to the environmental aspects and sustainability of agriculture are of growing importance and this has led to the collection of a suite of data beyond FADN requirements. This includes animal housing dates, proportion of manure stored as slurry and farm yard manure (FYM), proportion of manure generated by animal type, proportion of manure applied during different seasons, proportion of manure applied by different application methods, proportion of manure stored by type of storage method. **No data is available of sheep housing periods, so data presented in this report relates exclusively to bovine generated animal manure. However, sheep and tillage farms are included in this analysis as many have bovine activity**. Results are presented at an aggregate level and on a national, nitrate zone and farm system basis over the 2016 to 2018 period.

2.2 SAMPLE PROFILE AND POPULATION REPRESENTATION

Table 1 details the breakdown of the sample and population representativeness on a national, nitrate zone and farm system basis. It should be noted that when aggregate results are reported, the population represented is reflective of farms that have the relevant category of animal (e.g. suckler cows) and/or activity (e.g. slurry storage), hence for example any suckler cows held on dairy farms are included in the aggregate suckler cow category. Very small farms, defined as farms below the €8,000 standard output threshold are not included in the NFS annual survey sampling frame. Standard output measures are applied to each animal and crop output on the farm, a standard output of €8,000 or more is equivalent to 4 dairy cows, 5 hectares of wheat or 11 suckler cows. The Teagasc NFS sample is representative of 88.5% of the utilizable agricultural area, 97% of the standard agricultural output and 96% of livestock units in Ireland.

Table 1: Population of farms represented on a national, nitrate zone and farm system basis

National	2016	2017	2018
Sample number (farms)	877	876	876
Population represented	91,367	91,367	90,875

Nitrate Zone	2016	2017	2018
Zone A			
Sample Number (farms)	470	450	447
Population represented	34,596	34,596	34,553
Zone B			
Sample Number (farms)	322	319	315
Population represented	44,055	43,856	43,159
Zone C			
Sample Number (farms)	85	107	114
Population represented	12,495	12,371	12,438

Farm System	2016	2017	2018
Dairy			
Sample Number (farms)	324	309	310
Population represented	16,146	16,146	16,081
Cattle			
Sample Number (farms)	360	370	375
Population represented	54,020	54,020	53,651
Sheep			
Sample Number (farms)	123	125	124
Population represented	14,322	14,322	14,265
Tillage			
Sample Number (farms)	70	72	67
Population represented	6,879	6,879	6,879

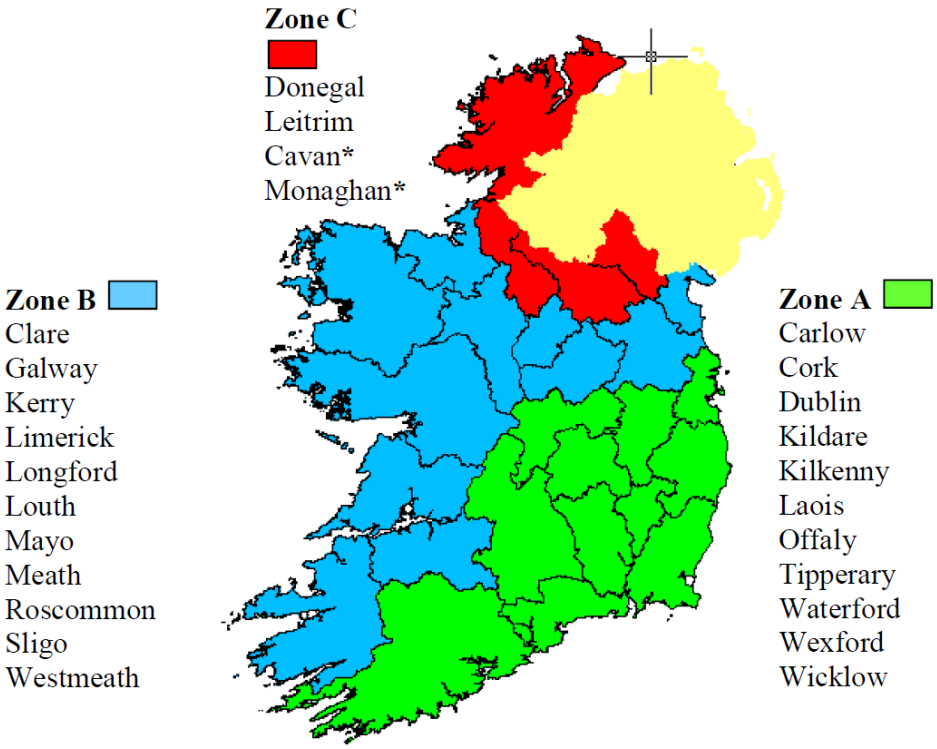
Source: Teagasc National Farm Survey

2.3 DEFINITION OF KEY VARIABLES

Aggregate Result: All results presented in this report are on an aggregated basis. All individual farm results are aggregated to produce aggregate national, zone or system level average results, as opposed to average farm level results.

Nitrate Zones: The EU Nitrates Directive National Action Programme was implemented on a whole territory basis in Ireland and the national territory was subdivided into three management zones (groups of counties) by reference mainly to land use class, rainfall and length of growing season. Regulations relating to nutrient management differ across these zones. These nitrate zones are displayed in Figure 1 below.

Figure 1: Nitrate Zone designation in Ireland under the EU Nitrates Directive



Source: Department of Agriculture, Food and the Marine (2014)

The most recent regulations that give effect to National Action Programme in this area were enacted through statutory instrument (SI) No. 65 of 2018 Good Agricultural Practice for Protection of Waters (GAP) Regulations (Government of Ireland, 2018, 2020). The GAP Regulations encompass rules on slurry storage capacity, application of inorganic and organic fertilisers, livestock stocking densities and farm facilities. Under the GAP Regulations, storage capacity on farm holdings across all zones must be sufficient for the full housing period and should provide an adequate level of storage to allow for circumstances where application might be hindered due to periods of adverse weather.

The following minimum storage capacity for bovine livestock manure are set down:

- 16 weeks in Zones A
- 18 weeks in Zone B, and
- 20 or 22[1] weeks in Zone C.

The periods during which the application of organic fertiliser are prohibited (both dates inclusive) are outlined in Table 2 below.

[1] Recognising the high water quality in counties Donegal and Leitrim and the lower intensity of agricultural production, the required minimum storage period was set at 20 weeks. The minimum storage period for counties Cavan and Monaghan was designated at 22 weeks

Table 2: Prohibition periods for spreading organic fertilisers

Zone	All Organic Fertilisers Excluding Farmyard Manure	Farmyard Manure
A	15 Oct. to 12 Jan.	1 Nov. to 12 Jan.
B	15 Oct. to 15 Jan	1 Nov. to 15 Jan.
C	15 Oct. to 31 Jan.	1 Nov. to 31 Jan.

Source: DAFM (2014)

Farm system: Within the Teagasc NFS, farms are classified into major farming systems according to the standardised EU typology used by FADN (a more detailed explanation can be found in Dillon et al., 2018). This report displays results for the four dominant farm systems namely, dairy, cattle, sheep and tillage.

Slurry – In this report slurry relates to animal manure stored in a liquid format. As no data is available on sheep housing dates, the results presented exclusively relate to bovine slurry. Quantities of slurry generated are estimated from animal numbers housed, the duration of housing and slurry coefficients per bovine animal category as per the Nitrates Regulations (S.I. No. 605 of 2017).

Farm Yard Manure (FYM) - In this report, FYM relates to animal manure stored in a more solid form (slurry mixed with straw). Again, as no data is available on sheep housing dates, meaning that the results presented exclusively relate to bovine FYM. Quantities of FYM generated are estimated from animal numbers housed, the duration of housing and FYM coefficients per bovine animal category as per the Nitrates Regulations (S.I. No. 605 of 2017).

Days Housed – The housing period was based on reported cattle turn out and turn in dates. A half day was assumed when animals were out by day and housed by night. Animal numbers housed were based on animal inventories held on December 31st each year over the study period. Only farms with the relevant animal category (e.g. dairy cows) were included in the analysis for that animal category.

Slurry applied by Season – Slurry applied by season was based on the total volume of slurry generated (based on the number and type of animal housed as well as number of days housed) and the percentage of slurry reported spread by farmers during the periods January-April, May-July, August-September and October-December.

FYM applied by Season – FYM applied by season was based on the total volume of FYM generated (based on the number and type of animal housed as well as number of days housed) and the percentage of FYM reported spread by farmers during the periods January-April, May-July, August-September and October-December. All FYM is assumed to be broadcast spread using either side discharge or rear discharge spreaders.

Slurry applied by different application methods – Slurry applied by season was based on the total volume of slurry generated (based on the number and type of animal housed as well as number of days housed) and the percentage of slurry reported spread using different methods (e.g. splash plate) either by the farmer or a contractor.

Slurry stored by type of storage method – Slurry stored by type of storage method was based on the total volume of slurry generated (based on the number and type of animal housed as well as number of days housed) and the percentage of slurry reported stored in different ways (e.g. underground tank under roofed slatted shed).

3 years average basis - Due to potential impact of weather shocks (positive and negative) results are presented on an individual and 3-year average basis.

Low emissions slurry spreading (LESS) – This covers slurry application by either trailing shoe or trailing hose.

3 RESULTS

Results are presented on a national, nitrate zone and farm system aggregate basis.

3.1 AGGREGATE RESULT – NATIONAL

Table 3 reports on the number of days housed by livestock category on a national aggregate basis. On average dairy cows and bulls were housed for the shortest period, at 121 days based on the 3 year average. Other livestock categories tended to be housed for between 147-150 days on average over the period examined.

Table 3: Number of days housed by bovine category on a national aggregate basis

	Annual Average Days Housed			3 Year Average
All Farms	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	117	120	125	121
Suckler Cows	145	154	151	150
Cattle 0 to 1 years	143	150	148	147
Cattle 1 to 2 years Female	146	152	150	149
Cattle 1 to 2 years Male	145	148	147	147
Cattle 2 to 3 years Female	150	152	146	149
Cattle 2 to 3 years Male	144	148	152	148
Bulls	117	120	125	121

Source: Teagasc National Farm Survey

On average over the 2016 to 2018 period, 81% of manure was stored as slurry and 19% was stored as FYM on an aggregate basis. The percentage stored as slurry tended to increase over the study period and conversely the percentage of manure stored as FYM declined, as seen in Table 4.

Table 4: Percentage of bovine manure stored as slurry & FYM on a national aggregate basis

	Annual Average			3 Year Average
All Farms	**2016**	**2017**	**2018**	**2016-18**
% Stored as slurry	79%	81%	82%	81%
% Stored as FYM	21%	19%	18%	19%

Source: Teagasc National Farm Survey

On average 94% of manure generated by dairy cows was stored as slurry. The next highest in relative terms was female cattle 2 to 3 years where 88% of manure was stored as slurry. This declined to 85-86% for cattle 1 to 2 years of age. For manure generated by suckler cows on average 82% was stored as slurry, this figure declined to 81% for bulls and male cattle 2 to 3 years old as illustrated by Table 5. The lowest proportion stored as slurry was among the cattle 0 to 1 years at 56%.

Table 5: Breakdown of bovine manure stored as slurry & FYM by animal type on an aggregate basis

	Annual % Average Slurry & FYM			3 Year Average
	2016	**2017**	**2018**	**2016-2018**
Dairy Cows:				
% Stored as slurry	93%	95%	94%	94%
% Stored as FYM	7%	5%	6%	6%
Suckler Cows:				
% Stored as slurry	80%	84%	83%	82%
% Stored as FYM	20%	16%	17%	18%
Cattle 0 to 1 years:				
% Stored as slurry	54%	57%	57%	56%
% Stored as FYM	46%	43%	43%	44%
Cattle 1 to 2 years Female:				
% Stored as slurry	84%	85%	87%	86%
% Stored as FYM	16%	15%	13%	14%
Cattle 1 to 2 years Male:				
% Stored as slurry	84%	85%	87%	85%
% Stored as FYM	16%	15%	13%	15%
Cattle 2 to 3 years Female:				
% Stored as slurry	87%	86%	90%	88%
% Stored as FYM	13%	14%	10%	12%
Cattle 2 to 3 years Male:				
% Stored as slurry	76%	81%	86%	81%
% Stored as FYM	24%	19%	14%	19%
Bulls:				
% Stored as slurry	74%	80%	88%	81%
% Stored as FYM	26%	20%	12%	19%

On average 30% of aggregate slurry generated (and stored) nationally was derived from dairy cows, while a further 25% was generated from suckler cows. Between 11-14% of aggregate slurry was derived from each of the cattle 0 to 1 years and cattle 1 to 2 year categories as outlined in Table 6.

Table 6: Percentage of total bovine slurry generated by animal type on an aggregate basis

	Annual % Average Slurry			3 Year Average
All Farms	**2016**	**2017**	**2018**	**2016-2018**
Dairy Cows	30%	30%	31%	30%
Suckler Cows	24%	26%	24%	25%
Cattle 0 to 1 years	14%	14%	13%	14%
Cattle 1 to 2 years Female	16%	14%	14%	14%
Cattle 1 to 2 years Male	11%	10%	12%	11%
Cattle 2 to 3 years Female	3%	3%	3%	3%
Cattle 2 to 3 years Male	1%	2%	2%	2%
Bulls	1%	1%	2%	1%

Source: Teagasc National Farm Survey

The majority of aggregated FYM generated (and stored) came from the cattle 0 to 1 year age category (46% on average over the 3 years). The suckler cow category was responsible for a further 22% on average nationally as seen in Table 7.

Table 7: Percentage of bovine FYM generated by animal type on a national aggregate basis

	Annual % Average FYM			3 Year Average
All Farms	**2016**	**2017**	**2018**	**2016-2018**
Dairy Cows	8%	8%	10%	9%
Suckler Cows	22%	22%	22%	22%
Cattle 0 to 1 years	45%	47%	46%	46%
Cattle 1 to 2 years Female	11%	10%	9%	10%
Cattle 1 to 2 years Male	7%	8%	8%	8%
Cattle 2 to 3 years Female	3%	3%	3%	3%
Cattle 2 to 3 years Male	1%	1%	1%	1%
Bulls	1%	1%	1%	1%

Source: Teagasc National Farm Survey

Table 8 indicated that 44% of slurry was applied to land between January and April on an average aggregate basis, a further 40% and 13% was applied between May-July and August-September respectively. On average 3% of total slurry was applied in October before the closed period.

Table 8: Percentage of bovine slurry applied by season on a national aggregate basis

	Annual Average			3 Year Average
All Farms	**2016**	**2017**	**2018**	**2016-18**
January-April	44%	46%	42%	44%
May-July	40%	40%	41%	40%
August-September	13%	11%	14%	13%
October-December	3%	3%	3%	3%

Source: Teagasc National Farm Survey

The largest proportion (44% on a 3-year average basis) of aggregate FYM was applied in August-September period, with a further 36% applied in October before the end of the closed period as outlined in Table 9.

Table 9: Percentage of bovine FYM applied by season on a national aggregate basis

	Annual Average			3 Year Average
All Farms	2016	2017	2018	2016-18
January-April	10%	12%	9%	10%
May-July	11%	9%	9%	10%
August-September	47%	45%	41%	44%
October-December	32%	34%	41%	36%

Source: Teagasc National Farm Survey

The majority of slurry was applied via the splash plate method – 84% on average over the study period on a national aggregate basis, as illustrated in Table 10. A further 10% was applied via an umbilical system (no data was available on the type of umbilical system) on average, while 3% was accounted for by LESS and 1% was applied via injection. It should be noted that the splash plate application method has declined and other methods have increased over the study period.

Table 10: Percentage of bovine slurry applied by different application methods on a national aggregate basis

		Annual Average		3 Year Average
Method of application (All Farms)	**2016**	**2017**	**2018**	**2016-18**
Splash plate	86%	85%	83%	84%
Injection	1%	1%	1%	1%
LESS	2%	3%	4%	3%
Umbilical*	9%	10%	11%	10%
Side End	1%	1%	1%	1%
Other	1%	0%	0%	1%

Source: Teagasc National Farm Survey * No data was available on type of umbilical system used

The vast majority of slurry was stored under a roofed slatted tank (87% on average over the 3 years) on average over the study period. A further 5% of slurry was stored in an unroofed underground tank, 4% of slurry was stored in both uncovered over ground tanks and covered over ground tanks. Lined lagoons account for 1% of total aggregate slurry storage nationally over the study period. Table 11 suggests a growing prevalence of storage via roofed slatted tank over the study period.

Table 11: Percentage of bovine slurry stored by storage method on a national aggregate basis

	Annual Average			3 Year Average
Slurry Storage Method (All Farms)	**2016**	**2017**	**2018**	**2016-18**
Under roofed slatted tank	85%	87%	89%	87%
Unroofed underground tank	6%	5%	4%	5%
Uncovered over ground tank	4%	4%	3%	4%
Covered over ground tank	4%	3%	3%	3%
Unlined lagoon	0%	0%	0%	0%
Lined lagoon	1%	1%	1%	1%

Source: Teagasc National Farm Survey * No data was available on type of umbilical system used

3.2 AGGREGATE RESULT – NITRATE ZONE

Table 12 outlines days housed by livestock category on an aggregate basis by nitrate zone. Farms in zone A had the shortest housing period on average over the study period (with an exception for the cattle 2-3 year categories versus zone B). Dairy cows in zone A for example were housed for 9% fewer days than dairy cows in zone B and 22% fewer days than dairy cows in zone C.

Table 12: Number of days housed by livestock category on an aggregate basis by Nitrate Zone

	Annual Average Days Housed			3 Year Average
Zone A	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	111	113	122	116
Suckler Cows	134	140	148	141
Cattle 0 to 1 years	141	145	145	144
Cattle 1 to 2 years Female	145	146	146	146
Cattle 1 to 2 years Male	144	147	152	148
Cattle 2 to 3 years Female	143	154	154	152
Cattle 2 to 3 years Male	153	156	148	152
Bulls	137	144	139	140

	Annual Average Days Housed			3 Year Average
Zone B	**2016**	**2017**	**2016-18**	**2016-18**
Dairy Cows	126	130	125	127
Suckler Cows	154	162	153	157
Cattle 0 to 1 years	142	152	151	148
Cattle 1 to 2 years Female	143	150	148	147
Cattle 1 to 2 years Male	145	157	145	149
Cattle 2 to 3 years Female	146	145	150	147
Cattle 2 to 3 years Male	145	146	145	146
Bulls	147	156	148	150

	Annual Average Days Housed			3 Year Average
Zone C	**2016**	**2017**	**2016-18**	**2016-18**
Dairy Cows	151	152	142	148
Suckler Cows	163	172	162	165
Cattle 0 to 1 years	161	164	158	161
Cattle 1 to 2 years Female	161	153	152	155
Cattle 1 to 2 years Male	172	162	151	161
Cattle 2 to 3 years Female	-*	145	162	154**
Cattle 2 to 3 years Male	-*	158	148	153**
Bulls	163	165	153	160

Source: Teagasc National Farm Survey
* No result reported due to small sample size
** Result is based on a 2 year average

Over the three-year study period, the highest proportion of bovine manure stored in slurry form was in zone C at 91%, followed by zone B at 89%, with the zone A at 74%. Conversely, 26% of aggregate manure in zone A was stored as FYM on a three-year average basis, this declined to 11% in zone B and 9% in zone C. The trend in Table 13 is toward storage of manure in slurry rather than FYM form.

Table 13: Percentage of aggregate bovine manure stored as slurry & FYM by nitrate zone

	Annual Average			3 Year Average
	2016	**2017**	**2018**	**2016-18**
Zone A				
% Stored as slurry	73%	74%	75%	74%
% Stored as FYM	27%	26%	25%	26%
Zone B				
% Stored as slurry	88%	89%	89%	89%
% Stored as FYM	12%	11%	11%	11%
Zone C				
% Stored as slurry	88%	91%	93%	91%
% Stored as FYM	12%	9%	7%	9%

Source: Teagasc National Farm Survey

On average 92% of manure generated by dairy cows was stored in slurry form in zone A. Excluding suckler cows and cattle 0 to 1 years, between 76-83% of aggregate manure was stored in slurry form across the other categories. This figure declined to 70% for suckler cows, while the majority of manure (57%) for cattle age 0 to 1 years was stored as FYM, as shown in Table 14.

Table 14: Proportion of aggregate bovine manure stored as slurry & FYM by animal type in zone A

	Annual % Average Slurry & FYM			3 Year Average
Zone A	**2016**	**2017**	**2018**	**2016-2018**
Dairy Cows:				
% Stored as slurry	92%	92%	91%	92%
% Stored as FYM	8%	8%	9%	8%
Suckler Cows:				
% Stored as slurry	69%	72%	70%	70%
% Stored as FYM	31%	28%	30%	30%
Cattle 0 to 1 years:				
% Stored as slurry	43%	42%	43%	43%
% Stored as FYM	57%	58%	57%	57%
Cattle 1 to 2 years Female:				
% Stored as slurry	83%	82%	83%	83%
% Stored as FYM	17%	18%	17%	17%
Cattle 1 to 2 years Male:				
% Stored as slurry	77%	77%	83%	79%
% Stored as FYM	23%	23%	17%	21%

	Annual % Average Slurry & FYM			3 Year Average
Zone A	**2016**	**2017**	**2018**	**2016-2018**
Cattle 2 to 3 years Female:				
% Stored as slurry	77%	77%	86%	80%
% Stored as FYM	23%	23%	14%	20%
Cattle 2 to 3 years Male:				
% Stored as slurry	68%	76%	84%	76%
% Stored as FYM	32%	24%	16%	24%
Bulls:				
% Stored as slurry	76%	79%	79%	78%
% Stored as FYM	24%	21%	21%	22%

Nearly all (99%) of manure generated by dairy cows was stored in slurry form in zone B, as illustrated in Table 15. Excluding bulls (80%) and cattle 0 to 1 years (72%), over 90% of aggregate manure was stored as slurry for the other livestock categories.

Table 15: Proportion of aggregate bovine manure stored as slurry & FYM by animal type in zone B

	Annual % Average Slurry & FYM			3 Year Average
Zone B	**2016**	**2017**	**2018**	**2016-2018**
Dairy Cows:				
% Stored as slurry	98%	99%	98%	99%
% Stored as FYM	2%	1%	2%	1%
Suckler Cows:				
% Stored as slurry	88%	91%	91%	90%
% Stored as FYM	12%	9%	9%	10%
Cattle 0 to 1 years:				
% Stored as slurry	71%	71%	73%	72%
% Stored as FYM	29%	29%	27%	28%
Cattle 1 to 2 years Female:				
% Stored as slurry	89%	87%	89%	88%
% Stored as FYM	11%	13%	11%	12%
Cattle 1 to 2 years Male:				
% Stored as slurry	93%	92%	94%	93%
% Stored as FYM	7%	8%	6%	7%
Cattle 2 to 3 years Female:				
% Stored as slurry	94%	91%	90%	92%
% Stored as FYM	6%	9%	10%	8%
Cattle 2 to 3 years Male:				
% Stored as slurry	97%	89%	89%	91%
% Stored as FYM	3%	11%	11%	9%
Bulls:				
% Stored as slurry	76%	82%	81%	80%
% Stored as FYM	24%	18%	19%	20%

Zone C was similar to zone B where 99% of manure generated by dairy cows was stored as slurry, as illustrated in Table 16. Again, excluding bulls (83%) and cattle 0 to 1 years (78%), the remaining categories indicated over 90% of aggregate manure was stored as slurry.

Table 16: Proportion of aggregate bovine manure stored as slurry & FYM by animal type in zone C

	Annual % Average Slurry & FYM			3 Year Average
Zone C	**2016**	**2017**	**2018**	**2016-2018**
Dairy Cows:				
% Stored as slurry	99%	99%	100%	99%
% Stored as FYM	1%	1%	0%	1%
Suckler Cows:				
% Stored as slurry	92%	94%	95%	94%
% Stored as FYM	8%	6%	5%	6%
Cattle 0 to 1 years:				
% Stored as slurry	76%	78%	80%	78%
% Stored as FYM	24%	22%	20%	22%
Cattle 1 to 2 years Female:				
% Stored as slurry	83%	95%	98%	91%
% Stored as FYM	17%	5%	2%	9%
Cattle 1 to 2 years Male:				
% Stored as slurry	95%	92%	92%	93%
% Stored as FYM	5%	8%	8%	7%
Cattle 2 to 3 years Female:				
% Stored as slurry	100%	99%	99%	99%
% Stored as FYM	0%	1%	1%	1%
Cattle 2 to 3 years Male:				
% Stored as slurry	95%	98%	94%	96%
% Stored as FYM	5%	2%	6%	4%
Bulls:				
% Stored as slurry	72%	81%	96%	83%
% Stored as FYM	28%	19%	4%	17%

The percentage of total aggregate slurry generated by animal type differs significantly across the zones, as seen in Table 17. The majority of total slurry generated and stored in zone A was derived from dairy cows at 40%. This reflects the greater concentration of dairy farms in this zone. In contrast, the majority of slurry generated in zones B and C were derived from suckler cows at 31% and 35% respectively, again reflecting the greater density of cattle rearing activities in these zones.

Table 17: Percentage of bovine slurry stored by animal type on an aggregate basis by nitrate zone

	Annual % Average Slurry			3 Year Average
Zone A	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	40%	40%	41%	40%
Suckler Cows	16%	17%	15%	16%
Cattle 0 to 1 years	12%	12%	10%	11%
Cattle 1 to 2 years Female	16%	15%	16%	16%
Cattle 1 to 2 years Male	11%	11%	12%	11%
Cattle 2 to 3 years Female	3%	3%	4%	3%
Cattle 2 to 3 years Male	1%	1%	1%	1%
Bulls	1%	1%	1%	1%
Zone B	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	25%	25%	24%	25%
Suckler Cows	30%	31%	31%	31%
Cattle 0 to 1 years	16%	15%	15%	15%
Cattle 1 to 2 years Female	13%	13%	13%	13%
Cattle 1 to 2 years Male	10%	10%	11%	10%
Cattle 2 to 3 years Female	2%	3%	3%	3%
Cattle 2 to 3 years Male	2%	2%	2%	2%
Bulls	1%	1%	1%	1%
Zone C	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	16%	21%	21%	19%
Suckler Cows	38%	36%	32%	35%
Cattle 0 to 1 years	19%	21%	19%	20%
Cattle 1 to 2 years Female	12%	8%	5%	8%
Cattle 1 to 2 years Male	13%	10%	14%	12%
Cattle 2 to 3 years Female	0%	1%	0%	0%
Cattle 2 to 3 years Male	1%	2%	3%	2%
Bulls	1%	1%	7%	3%

Source: Teagasc National Farm Survey

The majority of FYM generated and stored across all 3 zones was associated with the cattle 0-1 year category (45-54%) on a 3 year average aggregate basis (Table 18). Straw bedding is associated with calf rearing activity that corresponds to this age category.

Table 18: Percentage of bovine FYM generated and stored by animal type on an aggregate basis by nitrate zone

	Annual % Average FYM			3 Year Average
Zone A	**2016**	**2017**	**2018**	**2016-2018**
Dairy Cows	10%	10%	13%	11%
Suckler Cows	20%	20%	20%	20%
Cattle 0 to 1 years	45%	46%	45%	45%
Cattle 1 to 2 years Female	14%	13%	10%	12%
Cattle 1 to 2 years Male	6%	7%	8%	7%
Cattle 2 to 3 years Female	3%	3%	2%	3%
Cattle 2 to 3 years Male	1%	1%	1%	1%
Bulls	1%	1%	1%	1%
Zone B	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	5%	1%	3%	3%
Suckler Cows	29%	25%	26%	26%
Cattle 0 to 1 years	47%	47%	45%	46%
Cattle 1 to 2 years Female	7%	9%	7%	8%
Cattle 1 to 2 years Male	9%	12%	12%	11%
Cattle 2 to 3 years Female	1%	3%	3%	2%
Cattle 2 to 3 years Male	1%	1%	2%	2%
Bulls	2%	2%	2%	2%
Zone C	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	1%	2%	1%	1%
Suckler Cows	26%	23%	24%	25%
Cattle 0 to 1 years	44%	59%	61%	54%
Cattle 1 to 2 years Female	5%	7%	6%	6%
Cattle 1 to 2 years Male	21%	5%	3%	11%
Cattle 2 to 3 years Female	0%	0%	0%	0%
Cattle 2 to 3 years Male	0%	1%	0%	0%
Bulls	3%	2%	3%	3%

Source: Teagasc National Farm Survey

The majority of slurry applied in zone A was applied in the January to April period at 45%, a further 37% was applied in the May to July period on a 3 year average aggregate basis. These shares were reversed for zone B, where 46% was applied in May to July period and 41% in January to April. Zone C saw a relatively even split between January-April at 43% and May-July 42% as shown in Table 19.

Table 19: Percentage of bovine slurry applied by season on an aggregate basis by nitrate zone

	Annual Average			3 Year Average
Zone A	**2016**	**2017**	**2018**	**2016-2018**
January-April	45%	47%	44%	45%
May - July	37%	36%	37%	37%
August - September	13%	12%	14%	13%
October-December	5%	5%	5%	5%
Zone B	**2016**	**2017**	**2018**	**2016-18**
January-April	40%	42%	39%	41%
May - July	46%	45%	46%	46%
August - September	12%	11%	13%	12%
October-December	2%	2%	2%	1%
Zone C	**2016**	**2017**	**2018**	**2016-18**
January-April	42%	46%	40%	43%
May - July	39%	41%	48%	42%
August - September	18%	12%	11%	14%
October-December	1%	1%	1%	1%

Source: Teagasc National Farm Survey

The majority of FYM was applied in August and September in zone A (47%) and zone C (49%) on a 3 year average aggregate basis, as illustrated in Table 20. By contrast, the majority in zone B was applied from October to the end of the closed period for spreading (47%).

Table 20: Percentage of bovine FYM applied by season on an aggregate basis by nitrate zone

	Annual Average			3 Year Average
Zone A	**2016**	**2017**	**2018**	**2016-2018**
January-April	12%	12%	10%	11%
May - July	10%	8%	7%	8%
August - September	48%	48%	45%	47%
October-December	30%	32%	38%	34%
Zone B	**2016**	**2017**	**2018**	**2016-18**
January-April	4%	15%	6%	9%
May - July	17%	13%	17%	16%
August - September	34%	29%	25%	28%
October-December	45%	43%	52%	47%
Zone C	**2016**	**2017**	**2018**	**2016-18**
January-April	17%	13%	8%	13%
May - July	11%	9%	7%	9%
August - September	50%	53%	47%	49%
October-December	22%	25%	38%	29%

Source: Teagasc National Farm Survey

Splash plate was the pre-dominant method of slurry application in zone A at 91% on a 3 year average aggregate basis, declining to 83% and 63% for zone B and C respectively. Slurry application by an umbilical system was much more prevalent across zone C (25%) and zone B (13%) compared to zone A (5%). Low emissions slurry spreading method accounted for between 2-4% of aggregate slurry applications across the zones, as illustrated in Table 21.

Table 21: Percentage of bovine slurry applied by different methods on an aggregate basis by nitrate zone

Method of application	Annual Average			3 Year Average
Zone A	**2016**	**2017**	**2018**	**2016-2018**
Splash plate	91%	91%	89%	91%
Injection	0%	0%	0%	0%
LESS	2%	3%	4%	3%
Umbilical*	5%	5%	6%	5%
Side End	2%	1%	1%	1%
Other	0%	0%	0%	0%
Zone B	**2016**	**2017**	**2018**	**2016-18**
Splash plate	82%	84%	82%	83%
Injection	2%	1%	1%	1%
LESS	1%	2%	3%	2%
Umbilical*	14%	13%	13%	13%
Side End	1%	1%	1%	1%
Other	0%	0%	0%	0%
Zone C	**2016**	**2017**	**2018**	**2016-18**
Splash plate	64%	62%	64%	63%
Injection	1%	1%	1%	1%
LESS	1%	6%	6%	4%
Umbilical*	24%	25%	25%	25%
Side End	5%	3%	3%	4%
Other	5%	3%	2%	3%

Source: Teagasc National Farm Survey * No data was available on type of umbilical system

The majority of slurry was stored under a roofed slatted tank across all zones (87-94%), on a 3 year average aggregate basis, as outlined in Table 22.

Table 22: Percentage of bovine slurry stored by building structure on an aggregate basis by nitrate zone

	Annual Average			3 Year Average
Zone A % Slurry Stored in:	**2016**	**2017**	**2018**	**2016-2018**
Under roofed slatted tank	86%	87%	87%	87%
Unroofed underground tank	6%	6%	6%	6%
Uncovered over ground tank	4%	4%	3%	4%
Covered over ground tank	3%	2%	2%	2%
Unlined lagoon	0%	0%	1%	0%
Lined lagoon	1%	1%	1%	1%
Zone B Slurry Stored in:	**2016**	**2017**	**2018**	**2016-18**
Under roofed slatted tank	89%	91%	91%	91%
Unroofed underground tank	3%	1%	2%	2%
Uncovered over ground tank	1%	2%	1%	1%
Covered over ground tank	7%	6%	6%	6%
Unlined lagoon	0%	0%	0%	0%
Lined lagoon	0%	0%	0%	0%
Zone C Slurry Stored in:	**2016**	**2017**	**2018**	**2016-18**
Under roofed slatted tank	93%	95%	96%	95%
Unroofed underground tank	3%	2%	2%	2%
Uncovered over ground tank	4%	3%	2%	3%
Covered over ground tank	0%	0%	0%	0%
Unlined lagoon	0%	0%	0%	0%
Lined lagoon	0%	0%	0%	0%

Source: Teagasc National Farm Survey

3.3 AGGREGATE RESULT – FARM SYSTEM

The majority of bovine based animal manure was stored in slurry form on dairy, cattle and sheep farms (81-83%) over the study period. On tillage farms, farmyard manure storage was more prevalent accounting for 43% of aggregate cattle manure. Results for slurry and FYM storage proportions by farm type are shown in Table 23.

Table 23: Percentage of bovine manure stored as slurry & FYM on an aggregate basis by farm system

	Annual Average			3 Year Average
Dairy Farms	**2016**	**2017**	**2018**	**2016-18**
Stored as slurry	82%	83%	84%	83%
Stored as FYM	18%	17%	16%	17%
Cattle Farms				
Stored as slurry	79%	82%	82%	81%
Stored as FYM	21%	18%	18%	19%
Sheep Farms				
Stored as slurry	81%	81%	87%	83%
Stored as FYM	19%	19%	13%	17%
Tillage Farms				
Stored as slurry	52%	58%	62%	57%
Stored as FYM	48%	42%	38%	43%

Source: Teagasc National Farm Survey

Slurry was the pre-dominant storage method on dairy farms across all animal categories except for cattle 0-1 years where 61% of manure was stored as FYM as seen by Table 24.

Table 24: Percentage of bovine manure stored as slurry and FYM by animal type on dairy farms

	Annual % Average Slurry & FYM			3 Year Average
Dairy Farms	**2016**	**2017**	**2018**	**2016-2018**
Dairy Cows:				
% Stored as slurry	93%	94%	93%	94%
% Stored as FYM	7%	6%	7%	6%
Suckler Cows:				
% Stored as slurry	93%	93%	89%	92%
% Stored as FYM	7%	7%	11%	8%
Cattle 0 to 1 years:				
% Stored as slurry	41%	38%	39%	39%
% Stored as FYM	59%	62%	61%	61%
Cattle 1 to 2 years Female:				
% Stored as slurry	92%	91%	94%	92%
% Stored as FYM	8%	9%	6%	8%
Cattle 1 to 2 years Male:				
% Stored as slurry	87%	85%	87%	86%
% Stored as FYM	13%	15%	13%	14%
Cattle 2 to 3 years Female:				
% Stored as slurry	93%	99%	100%	97%
% Stored as FYM	7%	1%	0%	3%
Cattle 2 to 3 years Male:				
% Stored as slurry	100%	92%	99%	97%
% Stored as FYM	0%	8%	1%	3%
Bulls:				
% Stored as slurry	82%	83%	82%	82%
% Stored as FYM	18%	17%	18%	18%

Between 66% and 88% of manure on cattle farms was stored as slurry across all animal categories, as illustrated by Table 25. The cattle 0 to 1 years category had the greatest proportion of FYM at 34% on a 3 year average basis.

Table 25: Percentage of bovine manure stored as slurry and FYM by animal type on cattle farms

	Annual % Average Slurry & FYM			3 Year Average
Cattle Farms	**2016**	**2017**	**2018**	**2016-2018**
Dairy Cows:				
% Stored as slurry	0%	0%	0%	0%
% Stored as FYM	0%	0%	0%	0%
Suckler Cows:				
% Stored as slurry	80%	85%	84%	83%
% Stored as FYM	20%	15%	16%	17%
Cattle 0 to 1 years:				
% Stored as slurry	64%	69%	65%	66%
% Stored as FYM	36%	31%	35%	34%
Cattle 1 to 2 years Female:				
% Stored as slurry	89%	89%	88%	89%
% Stored as FYM	11%	11%	12%	11%
Cattle 1 to 2 years Male:				
% Stored as slurry	83%	87%	88%	86%
% Stored as FYM	17%	13%	12%	14%
Cattle 2 to 3 years Female:				
% Stored as slurry	78%	84%	86%	83%
% Stored as FYM	22%	16%	14%	17%
Cattle 2 to 3 years Male:				
% Stored as slurry	87%	87%	90%	88%
% Stored as FYM	13%	13%	10%	12%
Bulls:				
% Stored as slurry	69%	79%	78%	76%
% Stored as FYM	31%	21%	22%	24%

Slurry was again the dominant method of bovine manure storage on sheep farms. Between 67% and 96% of manure on sheep farms was stored as slurry across all animal categories as seen in Table 26. The cattle 0 to 1 year category again had the greatest proportion of FYM at 33% on an average 3 year basis.

Table 26: Percentage of bovine manure stored as slurry and FYM by animal type on sheep farms (with cattle)

	Annual % Average Slurry & FYM			3 Year Average
Sheep Farms (with Cattle)	**2016**	**2017**	**2018**	**2016-2018**
Dairy Cows:				
% Stored as slurry	0%	0%	0%	0%
% Stored as FYM	0%	0%	0%	0%
Suckler Cows:				
% Stored as slurry	83%	85%	90%	86%
% Stored as FYM	17%	15%	10%	14%
Cattle 0 to 1 years:				
% Stored as slurry	64%	65%	74%	67%
% Stored as FYM	36%	35%	26%	33%
Cattle 1 to 2 years Female:				
% Stored as slurry	88%	91%	93%	91%
% Stored as FYM	12%	9%	7%	9%
Cattle 1 to 2 years Male:				
% Stored as slurry	88%	77%	85%	83%
% Stored as FYM	12%	23%	15%	17%
Cattle 2 to 3 years Female:				
% Stored as slurry	93%	96%	96%	95%
% Stored as FYM	7%	4%	4%	5%
Cattle 2 to 3 years Male:				
% Stored as slurry	97%	97%	96%	96%
% Stored as FYM	3%	3%	4%	4%
Bulls:				
% Stored as slurry	76%	76%	70%	74%
% Stored as FYM	24%	24%	30%	26%

On tillage farms the majority of manure generated by suckler cows and cattle 0 to 1 years animal categories was stored as FYM (60-63% on average). This contrasted with storage practices for the other bovine categories where slurry was the pre-dominant storage method as seen by Table 27.

Table 27: Percentage of bovine manure stored as slurry and FYM by animal type on tillage farms (with cattle)

	Annual % Average Slurry & FYM			3 Year Average
Tillage Farms (with Cattle)	**2016**	**2017**	**2018**	**2016-2018**
Dairy Cows:				
% Stored as slurry	0%	0%	0%	0%
% Stored as FYM	0%	0%	0%	0%
Suckler Cows:				
% Stored as slurry	43%	39%	31%	37%
% Stored as FYM	57%	61%	69%	63%
Cattle 0 to 1 years:				
% Stored as slurry	28%	41%	50%	40%
% Stored as FYM	72%	59%	50%	60%
Cattle 1 to 2 years Female:				
% Stored as slurry	69%	72%	67%	70%
% Stored as FYM	31%	28%	33%	30%
Cattle 1 to 2 years Male:				
% Stored as slurry	53%	64%	71%	63%
% Stored as FYM	47%	36%	29%	37%
Cattle 2 to 3 years Female:				
% Stored as slurry	74%	69%	79%	74%
% Stored as FYM	26%	31%	21%	26%
Cattle 2 to 3 years Male:				
% Stored as slurry	53%	50%	70%	58%
% Stored as FYM	47%	50%	30%	42%
Bulls:				
% Stored as slurry	53%	61%	46%	53%
% Stored as FYM	47%	39%	54%	47%

Farm system type dictates the proportion of aggregate slurry generated by different animal categories, as can be observed in Table 28. On dairy farms, dairy cows generated 77% of total aggregate slurry, this contrasted with cattle and sheep farms, where greater proportions of cattle slurry were generated by suckler cows (41-47%) on a 3 year average aggregate basis. On tillage farms, the majority of slurry was associated with cattle 1-2 years of age (66%) on average.

Table 28: Percentage of bovine slurry generated by Animal Type on an aggregate basis by Farm System

	Annual Average % Slurry			3 Year Average
Dairy	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	73%	78%	79%	77%
Suckler Cows	1%	1%	1%	1%
Cattle 0 to 1 years	11%	8%	8%	9%
Cattle 1 to 2 years Female	5%	5%	4%	5%
Cattle 1 to 2 years Male	8%	7%	7%	7%
Cattle 2 to 3 years Female	1%	0%	0%	0%
Cattle 2 to 3 years Male	0%	0%	0%	0%
Bulls	1%	1%	1%	1%
Cattle	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	0%	0%	0%	0%
Suckler Cows	41%	42%	41%	41%
Cattle 0 to 1 years	18%	19%	17%	18%
Cattle 1 to 2 years Female	23%	20%	19%	21%
Cattle 1 to 2 years Male	12%	12%	15%	13%
Cattle 2 to 3 years Female	3%	4%	5%	4%
Cattle 2 to 3 years Male	2%	2%	2%	2%
Bulls	1%	1%	1%	1%
Sheep	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	0%	0%	0%	1%
Suckler Cows	50%	50%	44%	48%
Cattle 0 to 1 years	16%	17%	19%	17%
Cattle 1 to 2 years Female	15%	13%	15%	14%
Cattle 1 to 2 years Male	13%	12%	12%	12%
Cattle 2 to 3 years Female	2%	5%	6%	4%
Cattle 2 to 3 years Male	3%	2%	3%	3%
Bulls	1%	1%	1%	1%
Tillage	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	0%	0%	0%	0%
Suckler Cows	14%	9%	8%	9%
Cattle 0 to 1 years	6%	10%	12%	10%
Cattle 1 to 2 years Female	40%	44%	38%	41%
Cattle 1 to 2 years Male	27%	22%	24%	25%
Cattle 2 to 3 years Female	8%	8%	10%	9%
Cattle 2 to 3 years Male	4%	7%	8%	6%
Bulls	1%	0%	0%	0%

Source: Teagasc National Farm Survey

The majority of bovine based FYM generated on dairy farms was associated with cattle 0-1 years (67%), with a further 26% generated by dairy cows on an average aggregate basis, as illustrated in Table 29. For the cattle and sheep farms (who have cattle) the cattle 0-1 year and the suckler cow categories accounted for the majority of FYM (ranging between 35-40% depending on the category). For tillage farms with cattle, the FYM distribution was spread more broadly across the animal categories.

Table 29: Percentage of bovine FYM generated by Animal Type on an aggregate basis by Farm System

	Annual Average % FYM			3 Year Average
Dairy Farms	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	24%	23%	30%	26%
Suckler Cows	0%	0%	0%	0%
Cattle 0 to 1 years	68%	69%	64%	66%
Cattle 1 to 2 years Female	4%	4%	3%	4%
Cattle 1 to 2 years Male	3%	3%	2%	3%
Cattle 2 to 3 years Female	0%	0%	0%	0%
Cattle 2 to 3 years Male	0%	0%	0%	0%
Bulls	1%	1%	1%	1%
Cattle Farms	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	0%	0%	0%	0%
Suckler Cows	38%	34%	35%	36%
Cattle 0 to 1 years	37%	40%	39%	38%
Cattle 1 to 2 years Female	10%	11%	11%	11%
Cattle 1 to 2 years Male	9%	9%	9%	9%
Cattle 2 to 3 years Female	4%	4%	4%	4%
Cattle 2 to 3 years Male	1%	1%	1%	1%
Bulls	2%	1%	1%	1%
Sheep Farms	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	0%	0%	0%	0%
Suckler Cows	42%	37%	32%	37%
Cattle 0 to 1 years	39%	40%	43%	40%
Cattle 1 to 2 years Female	9%	5%	7%	7%
Cattle 1 to 2 years Male	7%	15%	13%	12%
Cattle 2 to 3 years Female	0%	1%	1%	1%
Cattle 2 to 3 years Male	1%	0%	1%	1%
Bulls	2%	2%	3%	2%
Tillage Farms	**2016**	**2017**	**2018**	**2016-18**
Dairy Cows	0%	0%	0%	0%
Suckler Cows	20%	18%	27%	22%
Cattle 0 to 1 years	19%	19%	19%	19%
Cattle 1 to 2 years Female	39%	34%	24%	32%
Cattle 1 to 2 years Male	13%	12%	19%	15%
Cattle 2 to 3 years Female	7%	12%	7%	9%
Cattle 2 to 3 years Male	1%	4%	3%	3%
Bulls	1%	1%	1%	0%

Source: Teagasc National Farm Survey

Tillage farms with cattle slurry tended to apply more proportionately in the January-April period at 58% on an average aggregate basis, as illustrated in Table 30. This was followed by dairy (46%), sheep farms with cattle (43%) and cattle farms (41%). Cattle and sheep farms tended to apply greater proportions in the May-June period (45% on average) compared to dairy (36%) and tillage farms (24%).

Table 30: Percentage of bovine slurry applied by season on an aggregate basis by Farm System

	Annual Average			3 Year Average
Dairy Farms	**2016**	**2017**	**2018**	**2016-2018**
January-April	46%	47%	45%	46%
May - July	36%	37%	37%	36%
August - September	14%	13%	15%	14%
October-December	4%	4%	4%	4%
Cattle Farms	**2016**	**2017**	**2018**	**2016-2018**
January-April	40%	44%	39%	41%
May - July	45%	43%	46%	45%
August - September	12%	10%	11%	11%
October-December	4%	3%	3%	3%
Sheep Farms	**2016**	**2017**	**2018**	**2016-2018**
January-April	46%	47%	36%	43%
May - July	43%	42%	48%	45%
August - September	11%	8%	16%	11%
October-December	0%	2%	0%	1%
Tillage Farms	**2016**	**2017**	**2018**	**2016-2018**
January-April	54%	60%	61%	58%
May - July	29%	22%	21%	24%
August - September	17%	17%	19%	18%
October-December	0%	0%	0%	0%

Source: Teagasc National Farm Survey

The majority of FYM tended to be applied in or after August (greater than 70%) across all farm systems, as seen by Table 31.

Table 31: Percentage of bovine FYM applied by season on an aggregate basis by Farm System

	Annual Average			3 Year Average
Dairy	**2016**	**2017**	**2018**	**2016-18**
January-April	9%	6%	7%	7%
May - July	6%	6%	8%	7%
August - September	43%	44%	34%	40%
October-December	42%	44%	51%	46%
Cattle				
January-April	8%	13%	10%	11%
May - July	16%	13%	11%	13%
August - September	42%	35%	38%	38%
October-December	34%	39%	41%	38%
Sheep				
January-April	18%	17%	14%	16%
May - July	4%	3%	2%	3%
August - September	65%	71%	55%	65%
October-December	13%	9%	29%	16%
Tillage				
January-April	18%	17%	9%	14%
May - July	6%	6%	2%	4%
August - September	69%	70%	72%	71%
October-December	7%	7%	17%	11%

Source: Teagasc National Farm Survey

Over 90% of cattle slurry applied on cattle, sheep and tillage farms was on average applied by the splash plate method, as illustrated in Table 32. This figure declined to 75% for dairy farms on average over the study period. Slurry application by umbilical systems was more prevalent on dairy farms, accounting for 17% of total aggregate slurry applied on average.

Table 32: Percentage of bovine slurry applied by different methods on an aggregate basis by farm system

	Annual Average			3 Year Average
Dairy Farm % applied by:	**2016**	**2017**	**2018**	**2016-18**
Slash plate	79%	75%	70%	75%
Injection	2%	2%	2%	2%
LESS	4%	5%	6%	5%
Umbilical*	14%	17%	21%	17%
Side End	1%	1%	1%	1%
Other	0%	0%	0%	0%
Cattle Farm % applied by:	**2016**	**2017**	**2018**	**2016-18**
Splash plate	90%	91%	91%	90%
Injection	0%	0%	0%	0%
LESS	1%	2%	2%	2%
Umbilical*	5%	5%	5%	5%
Side End	3%	1%	1%	2%
Other	1%	1%	1%	1%
Sheep Farm % applied by:	**2016**	**2017**	**2018**	**2016-18**
Splash plate	93%	93%	91%	92%
Injection	0%	0%	0%	0%
LESS	1%	2%	3%	2%
Umbilical*	3%	3%	3%	3%
Side End	0%	0%	2%	1%
Other	3%	2%	1%	2%
Tillage Farm % applied by:	**2016**	**2017**	**2018**	**2016-18**
Splash plate	100%	99%	97%	99%
Injection	0%	0%	1%	0%
LESS	0%	0%	0%	0%
Umbilical*	0%	0%	1%	0%
Side End	0%	1%	1%	1%
Other	0%	0%	0%	0%

Source: Teagasc National Farm Survey * No data available on type of umbilical system used

Over 97% of cattle manure that was stored as slurry was stored under a roofed slatted tank across cattle, sheep and tillage farms, as illustrated in Table 33. The figure was 79% on dairy farms on average over the 3-year period, with unroofed underground tanks, covered over ground tanks and uncovered over ground tanks accounting for 8%, 7% and 5% respectively.

Table 33: Percentage of bovine slurry stored by building structure on an aggregate basis by farm system

	Annual Average			3 Year Average
Dairy Farm Slurry % Stored in:	**2016**	**2017**	**2018**	**2016-18**
Under roofed slatted tank	77%	79%	81%	79%
Unroofed underground tank	9%	8%	7%	8%
Uncovered over ground tank	6%	5%	4%	5%
Covered over ground tank	7%	7%	6%	7%
Unlined lagoon	0%	0%	1%	0%
Lined lagoon	1%	1%	1%	1%
Cattle Farm Slurry % Stored in:	**2016**	**2017**	**2018**	**2016-18**
Under roofed slatted tank	96%	97%	97%	97%
Unroofed underground tank	2%	1%	1%	1%
Uncovered over ground tank	2%	2%	2%	2%
Covered over ground tank	1%	0%	0%	0%
Unlined lagoon	0%	0%	0%	0%
Lined lagoon	0%	0%	0%	0%
Sheep Farm Slurry % Stored in:	**2016**	**2017**	**2018**	**2016-18**
Under roofed slatted tank	96%	95%	98%	97%
Unroofed underground tank	1%	1%	1%	1%
Uncovered over ground tank	3%	4%	0%	2%
Covered over ground tank	0%	0%	1%	0%
Unlined lagoon	0%	0%	0%	0%
Lined lagoon	0%	0%	0%	0%
Tillage Farm Slurry % Stored in:	**2016**	**2017**	**2018**	**2016-18**
Under roofed slatted tank	100%	100%	100%	100%
Unroofed underground tank	0%	0%	0%	0%
Uncovered over ground tank	0%	0%	0%	0%
Covered over ground tank	0%	0%	0%	0%
Unlined lagoon	0%	0%	0%	0%
Lined lagoon	0%	0%	0%	0%

Source: Teagasc National Farm Survey

4 SUMMARY CONCLUSION

This reports aims to provide data on national level activity around manure management practices, with a view to assisting policymakers in the area of Nitrates Directive as well as GHG and air pollutant inventory development. Results relate to bovine generated animal manure and are presented at an aggregate level, on a national, nitrate zone, and farm system basis over the 2016 to 2018 period.

National Aggregate Level: On average over the study period, dairy cows and bulls were housed for 121 days while other livestock categories tend to be housed for between 147-150 days. In all, 81% of manure was stored as slurry and 19% FYM. Slurry / FYM storage ratios ranged from 94%/6% for dairy cows to 56%/44% for cattle 0 to 1 years respectively. In aggregate terms, 30% of slurry was derived from dairy cows, 25% from suckler cows and 11-14% from each of the cattle 0 to 1 years and cattle 1 to 2 year age categories. Conversely, 46% of aggregate FYM was derived from the cattle 0 to 1 year age category with suckler cows responsible for a further 22%. A total of 44% of slurry was applied to land between January and April, with a further 40%, 13% and 3% was applied between May-July, August-September, October-December respectively. The application of FYM was on the other hand concentrated at the back end of the year with 44% of average aggregate FYM applied in August-September, with a further 36% applied in October-December. The vast majority of slurry (84%) on a national basis was applied via the splash plate method, with a further 10%, 3% and 1% by umbilical, LESS and injection methods respectively. The majority of aggregate slurry (87%) was stored under a roofed slatted tank.

Nitrate Zone Aggregate Level: On average, farms in zone A had the shortest livestock housing periods. A total of 74%, 89% and 91% of bovine manure was stored as slurry in zone A, B, and C respectively, with the remainder stored as FYM on an average aggregate basis. A higher ratio of FYM storage (versus slurry) were associated with cattle 0 to 1 years across the zones compared to the other animal categories. In terms of slurry origin, 40% of aggregate in zone A was derived from dairy cows, whereas 31% and 37% of slurry generated in zones B and C was derived from suckler cows. Aggregate FYM generation across the 3 zones was generally (45-54%) associated with the cattle 0-1 year category. Timing of slurry application differed across the zones, with the majority of slurry in zones A and C applied between January-April, at 45% and 43% respectively, whereas 46% was applied between May and July in zone B. Conversely, the majority of FYM was after July. Splash plate accounted for 91%, 83% and 63% of slurry applications across zones A, B and C respectively. An umbilical system accounted for a further 5%, 13% and 25% respectively, with LESS accounted for between 2-4% of slurry applications across the zones. Slurry storage under a roofed slatted shed was the dominant structure by which slurry was stored (87-94%).

Farm System Aggregate Level: A total of between 81-83% of bovine based animal manure was stored in slurry form on dairy, cattle and sheep farms. Farm type dictated the source of slurry and FYM generation. For example, 77% of slurry on dairy farms was generated by dairy cows, whereas 41-47% of slurry on cattle and sheep farms was generated by suckler cows. Additionally, 66% of FYM generated on dairy farms was associated with cattle 0-1 years, whereas on cattle and sheep farms, the cattle 0-1 year old and the suckler cow categories both were significant sources of FYM. Tillage farms with bovine slurry tended to apply more proportionately in the January-April period at 58% of total slurry, followed by dairy (46%), sheep farms with cattle (43%) and cattle farms (41%). Cattle and sheep farms tended to apply greater proportions in the May-June period (45% on average) compared to dairy (36%) and tillage farms (24%). Conversely, the majority of FYM tended to be applied in or after August (greater than 70%) across all farm systems. Results indicated that over 90% of bovine slurry applied on cattle, sheep and tillage farms was by the splash plate method, this number declined to 75% for dairy farms. Over 97% of cattle manure that is stored as slurry is stored under a roofed slatted tank across cattle, sheep and tillage farms. The figure on average declined to 79% for dairy farms.

5 BIBLIOGRAPHY

Buckley, C., Donnellan, T., Dillon, E., Hanrahan, K., Moran, B. and Ryan, M., 2019. Teagasc National Farm Survey 2017 Sustainability Report. Available: https://www.teagasc.ie/media/website/publications/2019/2017-sustainability-report-250319.pdf

Burchill, W., Lanigan, G.J., Forrestal, P.J., Misselbrook, T., Richards, K.G., 2017. Ammonia emissions from urine patches amended with N stabilized fertilizer formulations. Nutrient Cycling Agroecosystems 108, 163-175

Department of Agriculture Food and the Marine (2014). Explanatory handbook for Good Agricultural Practice for the Protection of Waters Regulation 2014. https://www.agriculture.gov.ie/media/migration/ruralenvironment/environment/nitrates/2018Nitratesexplanatoryhandbook03042018.pdf

Dillon, E., Moran, B., Lennon, J., Donnellan, T., 2018. Teagasc National Farm Survey 2018 Results. Available: https://www.teagasc.ie/media/website/publications/2019/NFS-2018_final_web.pdf

Duffy, P., Black, K., Fahey, D., Hyde, B., Kehoe, A., Murphy, J., Quirke, B., Ryan, A.M. & Ponzi, J. 2020. Ireland National inventory report 2020 greenhouse gas emissions 1990 - 2018 reported to the United Nations framework convention on climate change. Available at: http://www.epa.ie/pubs/reports/air/airemissions/ghg/nir2020/NIR%202020_Merge_finalv2.pdf

EPA. 2019. Ireland's transboundary gas emissions 1990-2030. Environmental Protection Agency. Available at: https://www.epa.ie/pubs/reports/air/airemissions/irelandsairpollutantemissions2017/Irelands%20Air%20Pollutant%20Emissions%202017.pdf

Government of Ireland, 2006. European Communities (Good Agricultural Practice for Protection of Waters) Regulations (2006). S.I. No. 378 of 2006. Published by the Stationery Office, Government Publications Office, Dublin

Government of Ireland, 2009. European Communities (Good Agricultural Practice for Protection of Waters) Regulations (2009). S.I. No. 101 of 2009. Published by the Stationery Office, Government Publications Office, Dublin

Government of Ireland, 2010. European Communities (Good Agricultural Practice for Protection of Waters) Regulations (2010). S.I. No. 610 of 2010. Published by the Stationery Office, Government Publications Office, Dublin

Government of Ireland, 2014. European Communities (Good Agricultural Practice for Protection of Waters) Regulations (2014). S.I. No. 31 of 2014. Published by the Stationery Office, Government Publications Office, Dublin

Government of Ireland, 2017. European Communities (Good Agricultural Practice for Protection of Waters) Regulations (2017). S.I. No. 605 of 2017. Published by the Stationery Office, Government Publications Office, Dublin

Government of Ireland, 2018. European Communities (Good Agricultural Practice for Protection of Waters) Regulations (2018). S.I. No. 65 of 2018. Published by the Stationery Office, Government Publications Office, Dublin

Government of Ireland, 2020. European Communities (Good Agricultural Practice for Protection of Waters) Regulations (2020). S.I. No. 40 of 2020. Published by the Stationery Office, Government Publications Office, Dublin

Hennessy, T., Buckley, C., Cushion, M., Kinsella, A., Moran, B. 2011. National Farm Survey of Manure Application and Storage Practices on Irish Farms. Available: https://www.teagasc.ie/media/website/publications/2011/TeagascNationalFarmSurveyOfManureApplication.pdf

Hyde, B., Carton, O., and Murphy, W., 2008. Teagasc Farm Facilities Survey – Ireland 2003. Report produced for the Department of Agriculture, Fisheries and Food.

Kavanagh, I., Burchill, W., Healy, M.G., Fenton, O., Krol, D., Lanigan, G., 2019. Mitigation of ammonia and greenhouse gas emissions from stored cattle slurry using acidifiers and chemical amendments. Journal of Cleaner Production, 237, 1-8.