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Manure Storage on Canadian Farms from the Farm Environmental Management Survey (FEMS) 2011

Canada

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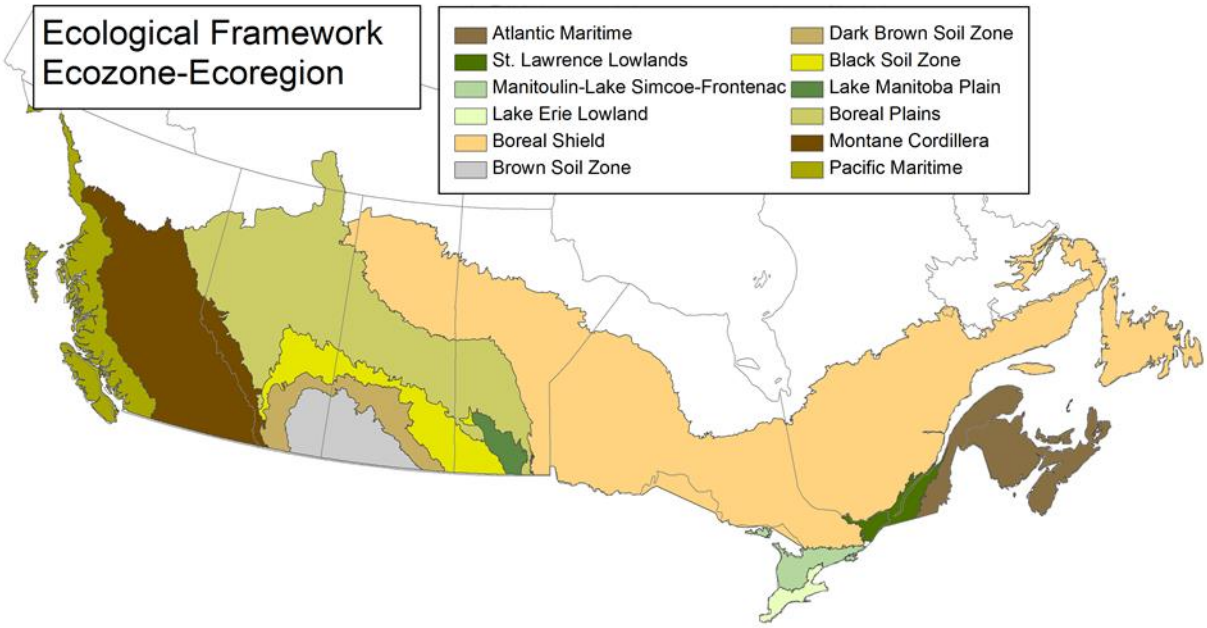
Executive Summary

This report provides key findings regarding Canadian manure storage and treatment practices as reported in the Farm Environmental Management Survey (FEMS) 2011 survey. The FEMS 2011 survey was conducted by Statistics Canada in partnership with Agriculture and Agri-Food Canada (AAFC). Results are provided for Canada as a whole, and also smaller units such as province, ecoregion, or livestock sector. Results are always provided on a percent of farms basis.



Source: Statistics Canada

1. Number of Liquid Manure Storage Systems

Across Canada, 70% of farms reported only one storage system, 20% have 2 systems, 6% have 3 systems, and 4% have more than 3 systems. Higher values of >1 system were found in B.C., Nova Scotia, the Brown Soil Zone, and the pork sector. There is some uncertainty of these results since the questionnaire did not specify if multi-cell lagoons should be considered as single or multiple systems. Remaining analysis of liquid manure storages involved only the primary storage structure on each farm.

2. Type of Manure Storage

a) Solid Manure

Most manure was stored in a pile on the ground outside the barn (50% of farms) or in an outdoor manure pack in corrals, pens, or feeding sites (45%). A smaller percentage of farms had manure on a bedding pack in barns (26%) or in a specialized storage structure (7%). These values add up to >100 since farms could report more than one type of storage.

Outdoor manure packs were more common in prairie provinces/ecoregions and the beef sector. Outside piles were more common in Atlantic provinces and Ontario. Barn bedding packs were more common in Ontario and PEI. Specialized storage structures were found primarily in Quebec (31%).

b) Liquid Manure

Most manure was stored in above ground tanks (40% of farms), earthen lagoons (25%), or below ground pits (21%). A smaller percentage of farms had manure in a pit/tank below slats in the barn (9%) or used other structures types (6%) such as partial above & below ground tanks/pits.

Above ground tanks were more common in the Atlantic Maritime and St. Lawrence Lowland ecoregions and the province of Quebec. Earthen lagoons were more common in Atlantic and prairie provinces. Below ground pits were more common in the B.C. and southern Ontario ecoregions.

Type of manure storage did not vary greatly between different livestock sectors.

3. Use of a Roof or Cover

a) Solid Manure

The vast majority of farms (88%) did not use any roof or cover over their manure storage(s). Seven percent covered all of their storages and five percent covered some of their storages.

These values did not vary geographically, except for more farms in Quebec (28%) and the Pacific Maritime ecoregion (37%) that covered all of their storages. Covered storage was also more common in the poultry (31%) and dairy (19%) sectors, and usually involved specialized storage structures. However, this question was not asked for barn bedding packs or pits below buildings, because a roof is inherently part of these barns/buildings.

b) Liquid Manure

A large majority of farms (74%) did not use any roof or cover over their primary manure storage. Remaining farms covered their primary storage with concrete (12%), a structure with a roof (9%), or other material such as straw, tarp, or geomembrane (6%).

Concrete covers were most common with pits/tanks below slats in buildings. Covers were more common in the Pacific Maritime (42%) and southern Ontario ecoregions (36%).

4. Use of a Concrete or Other Impermeable Pad for Solid Manure Storage

Across Canada, 34% used impermeable pads on all storages, and 11% used pads on some storages.

Impermeable pads occurred on 70 - 90% of farms, for storage types associated with improved infrastructure (e.g. barn bedding pack, pit below building, and specialized storage structures). For other storage types (e.g. outside manure pack and outside pile) only 20 - 40% of farms used impermeable pads.

Use of impermeable pads for all storages was much less in the prairie provinces/ecoregions and the Montane Cordillera ecoregion (6 to 12%), than other areas of Canada (40 to 70%). Impermeable pads were used much less in the beef sector (30%), than other livestock sectors (60 - 80%).

5. Runoff Containment for Solid Manure Storage

Across Canada 28% of farms used runoff containment for all storages, while 9% had runoff containment for some of their storages.

Runoff containment was most common for specialized storage structures (75%), and less common for outside manure packs or piles on the ground (33%). Note that this question was not asked for barn bedding packs or pits below buildings, as containment would be an inherent feature of these structures.

Runoff containment was most common in Quebec (60%), and least common in prairie provinces / ecoregions (25%). Runoff containment was less prevalent in the beef sector (30%), than other livestock sectors (50 - 60%).

6. Depth of Primary Liquid Manure Storage System

Depth of manure storages varied considerably: from < 8 feet (27%), 9 - 11 feet (15%), 12 - 13 feet (34%), >13 - 16 feet (18%), and > 16 feet (6%).

Pits/tanks below slats in building tended to be shallower (64% < 8 feet), while earthen lagoons were deeper (40% > 13 feet).

Shallower depths were more common in B.C. (66% < 12 feet), with deeper depths more prevalent in the prairie provinces (34% > 13 feet. Quebec had the highest percent of farms in the mid-size depth range (44% 12 - 13 feet).

There were few differences in depth between livestock sectors.

7. Storage Capacity (Months) for Primary Liquid Manure Storage System

Length of storage capacity varied considerably: from < 6 months (8%), 6 to < 9 months (32%), 9 to < 12 months (23%), and > or = 12 months (37%).

Storage capacity was least for pits/tanks below slats in building (52% < 9 months), and greatest for earthen lagoons (47% > or = 12 months). Above ground tanks tended to have more storage capacity than below ground pits.

Storage capacity was least in B.C. (84% < 9 months), and greatest in Manitoba (70% > or = 12 months). Quebec and Alberta also had a large portion of farms with > or = 9 months storage capacity, 72% and 61%, respectively.

There was little difference in storage capacity between livestock sectors.

8. Adoption of Multiple Practices

a) Solid Manure

Across Canada, only 6.5% of farms utilized all three practices: roof or cover, impermeable pad, and runoff containment. In Quebec this value was considerably higher than other provinces (24%).

Twenty percent of farms used two practices, 15% used one practice, and 43% used none. The highest percent of farms using none of these practices was in the prairie provinces (61%). Also, the beef sector had a higher percentage of farms using none of these practices (53), compared to other livestock sectors.

b) Liquid Manure

Storages with roofs or covers tended to have shallower depths and less storage capacity, compared to storages with no roof or cover. For storages with no roof or cover, there was also a trend toward deeper manure storages as storage capacity increases from < 9 months to > 9 months.

9. Distance to Nearest Surface Water

a) Solid Manure

A large majority of farms with solid manure storage had no surface water (33%) or the surface water is located > 90 meters from the storage (57%). These values did not change greatly for different storage types, ecoregions, provinces, or livestock sectors.

b) Liquid Manure

A large majority of farms with liquid manure storage had no surface water (55%) or the surface water is located > 90 meters from the primary storage (34%). These values did not change greatly for different storage types, ecoregions, provinces, or livestock sectors.

10. Distance to Nearest Well

a) Solid Manure

A majority of farms (65%) had a separation distance of > 90 meters from their solid manure storages to the nearest well. The remaining farms had separation distances of 60 - 90 meters (9%), 30 - 60 meters (10%), < 30 meters (4%), or had no wells on their farm (12%). These values did not change greatly for different storage types, ecoregions, provinces, or livestock sectors. However, there were somewhat more farms with separation distances > 90 meters in the prairie provinces. Also, pits below buildings tended to be located closer to wells than other manure storage types.

b) Liquid Manure

A slight majority of farms (55%) had a separation distance of > 90 meters from their primary liquid manure storage to the nearest well. The remaining farms had separation distances of 60 - 90 meters (17%), 30 - 60 meters (11%), < 30 meters (3%), or had no wells on their farm (14%). These values did not change greatly for different storage types, ecoregions, provinces, or

livestock sectors. However, there were somewhat more farms with separation distances > 90 meters in the prairie provinces. Also, pits/tanks below slat in buildings tended to be located closer to wells than other manure storage types.

11. Manure Treatment Practices

a) Solid Manure

Most farms did not treat solid manure (73%). The most common treatment practice was mixing or turning to accelerate composting (24%). Other practices such as mixing additives to modify odour, anaerobic digestion, and combinations of various treatments occurred on very few farms (3%). These values did not change greatly for different ecoregions, provinces, or livestock sectors, except for less composting in Quebec/Ontario (10%) and Atlantic provinces (16%), and more in prairie provinces (35%).

b) Liquid Manure

About half of farms did not treat liquid manure (51%). The most common treatment practice was aeration or agitation (45%). Other practices included mixing additives to modify odour, pH, or nutrient content (7%) and solid /liquid separation (4%). These values did not change greatly for different ecoregions, provinces, or livestock sectors, except for more aeration or agitation in the Pacific Maritime ecoregion (73%).

A. Introduction

This report provides key findings regarding Canadian manure storage and treatment practices as reported in the Farm Environmental Management Survey (FEMS) 2011 survey. The FEMS 2011 survey was conducted by Statistics Canada in partnership with Agriculture and Agri-Food Canada (AAFC). Analysis and results provided in this report were generated by AAFC's Science and Technology Branch (STB). Specific aspects of manure storage management included in this report are type of storage structure, use of a roof or cover, distance to nearest surface water, distance to nearest well, and manure treatment practices. Additional practices for solid manure storage include use of a concrete or other impermeable pad, and runoff containment. Additional practices for liquid manure include number of storages, depth of primary storage, and storage capacity (months) for the primary storage. Finally, this report compliments another FEMS 2011 report entitled “Canadian Manure Management Practices on Cropland”.

B. Geographic and Sector Framework

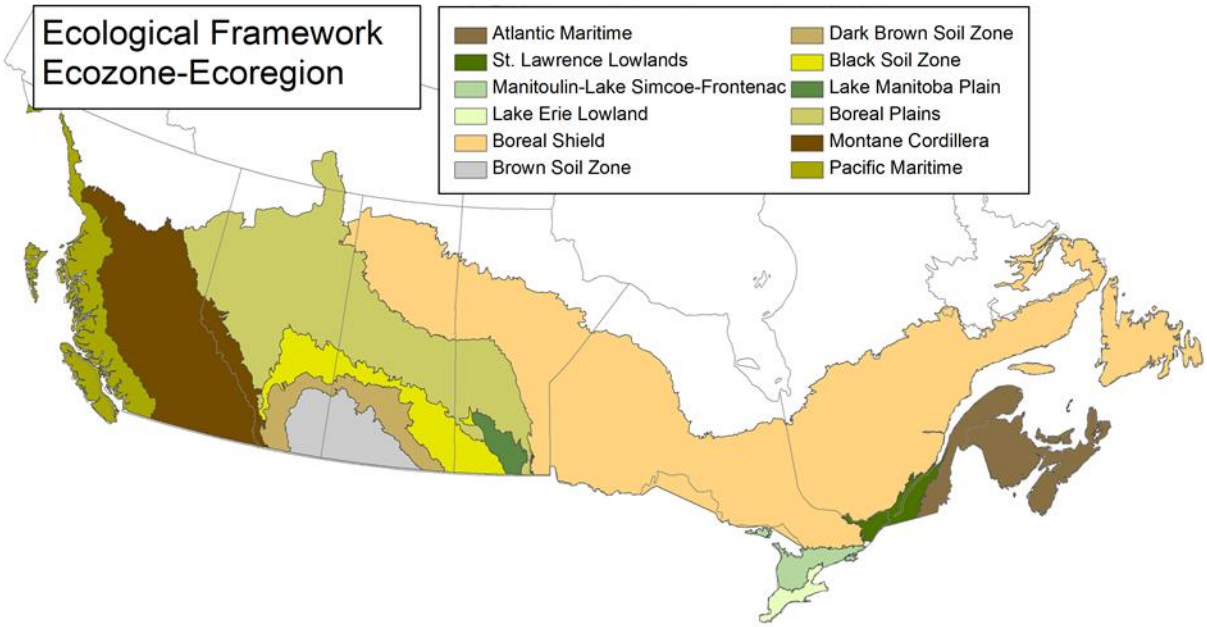
Results are provided by province and by ecozones-ecoregions. Ecozones-ecoregions are based on Canada’s national ecological framework (see the following website: http://sis.agr.gc.ca/cansis/nsdb/ecostrat/index.html). In this framework, large ecozones are made up of smaller ecoregions. For this survey, only ecozones with significant agricultural land were chosen, and some ecoregions were used for areas with higher areas of agricultural land and/or number of farms. The relationship between the national ecological framework and the FEMS ecozones-ecoregions is shown in Table 1. The FEMS ecozones-ecoregions are shown in Figure 1.

Table 1: Relationship Between Canada's Ecological Framework and FEMS Ecozone-Ecoregions

Canada's National Ecological Framework		FEMS Ecozone-Ecoregion
Ecozones	Ecoregions	
Atlantic Maritime		Atlantic Maritime
Mixedwood Plains	St. Lawrence Lowlands	St. Lawrence Lowlands
	Manitoulin-Lake Simcoe	Manitoulin-Lake Simcoe-Frontenac
	Frontenac	
	Lake Erie Lowland	Lake Erie Lowland
Boreal Shield		Boreal Shield
Prairies	Mixed Grassland	Brown Soil Zone
	Cypress Upland	
	Fescue Grassland	Dark Brown Soil Zone
	Moist Mixed Grassland	
	Aspen Parkland	Black Soil Zone
	Boreal Transition	
	Lake Manitoba Plain	Lake Manitoba Plain
Boreal Plains		Boreal Plains
Montane Cordillera		Montane Cordillera
Pacific Maritime		Pacific Maritime

Source: Environment Canada and Agriculture and Agri-Food Canada

Figure 1: FEMS Ecozones-Ecoregions

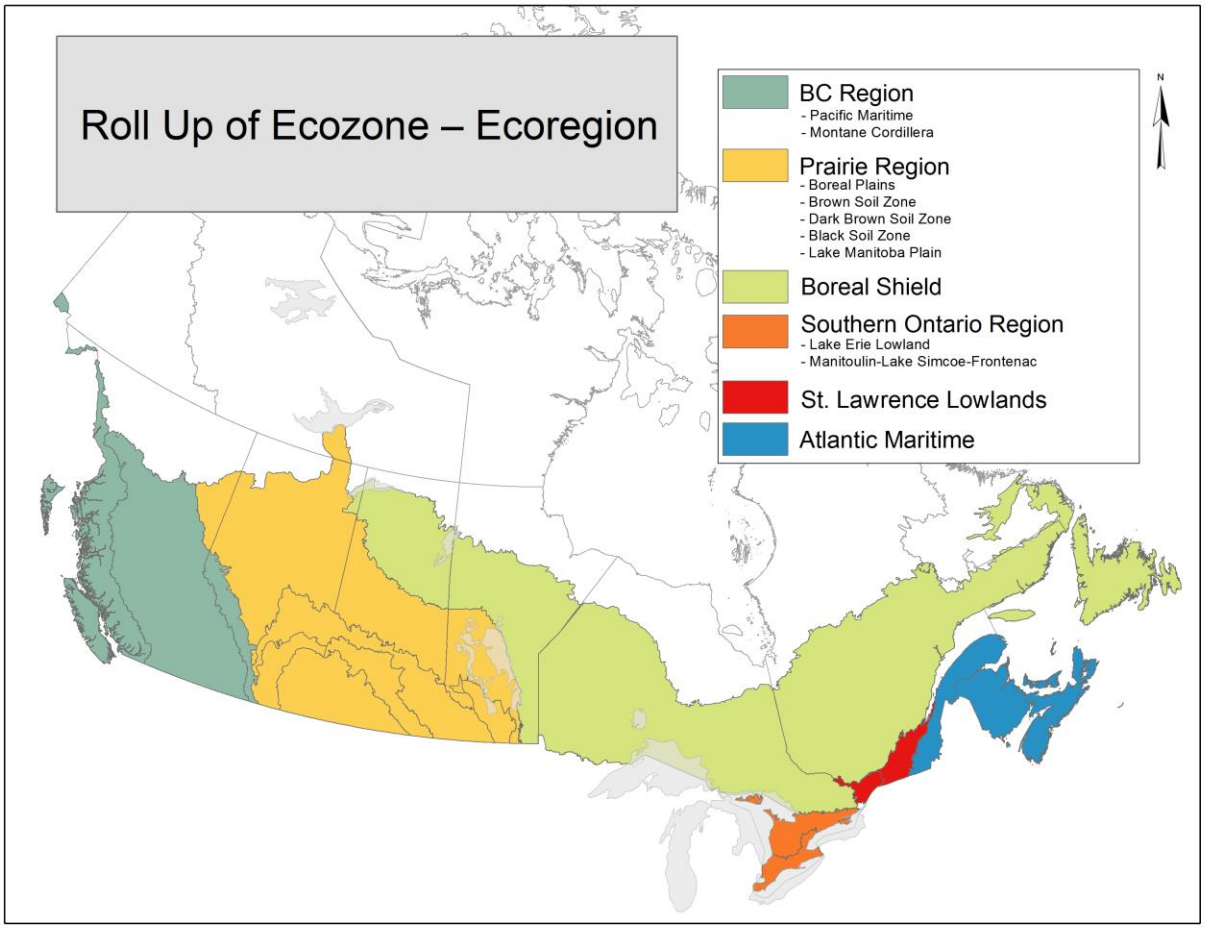


Source: Statistics Canada

For provincial reporting, results are also provided based on groups of provinces that have similar climate. Similarly, for ecozone-ecoregion reporting, results are also provided based on a roll up of groups that have similar climate, as shown in Figure 2.

Results are also provided based on livestock sector storing manure, such as dairy, beef, pork, poultry and other livestock. Hereinafter, for this report, “ecozones-ecoregions” are referred to as ecoregions for simplicity sake.

Figure 2: Roll Up of FEMS Ecozones-Ecoregions



Source: Statistics Canada and Agriculture and Agri-Food Canada

Results are also provided based on livestock sector storing manure, such as dairy, beef, pork, poultry and other livestock. Hereinafter, for this report, “ecozones-ecoregions” are referred to as ecoregions for simplicity sake.

C. Survey Design and Analysis Methods

The FEMS survey was designed as two separate modules, livestock and crop, with farms completing only one of the two modules to reduce survey burden. About 7,000 farms completed each module, amounting to about 6.3% of all farms in Canada. Farms were selected from Statistics Canada's Farm Register (based on 2011 Census of Agriculture data) to adequately represent different regions and production sectors across the country. To be selected for the livestock module farms had to be classified as a livestock or mixed farm, while for the crop module they were classified as crop or mixed farms, as defined by the farm registry. More information on the survey design and questionnaires can be found at: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5044&Item_Id=122432

Questions pertaining to manure storage and treatment in the farmyard were only asked in the livestock module. Similar questions were asked separately for solid manure, and liquid or semi-solid manure (Note: The latter is simply referred to as "liquid" from now on). However, as shown in Table 1, for many farms questions on only one type of manure were asked based on a screening question that first asked farmers which type of manure they spread more of on their operation. As a general rule farms that spread more liquid manure were not asked questions about solid manure, and farms that spread more solid manure were not asked questions about liquid manure. About 3 times more farmers answered questions pertaining to solid manure than liquid manure.

Table 1: Percentage of Farms Answering Questions on Liquid and Solid Manure Storage based on a Screening Question asking Which Type of Manure was Spread on Land More

Farms that Spread More Of	**Farms Answering Manure Storage Questions for**	
	Liquid Manure (%)	**Solid Manure (%)**
Solid		47.3
Liquid or semi-solid	6.2	
Spread same amount of both	18.4	16.8
Did not spread manure	1.1	10.2
Total	25.7	74.3

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)
Note for Table 1: Percent values add up to 100.

Results are always reported on a percentage of farms basis, not the actual number of farms. Therefore, while this analysis involves a subset of total farms, the sample size in most cases is considered large enough to represent reasonably well geographic regions or sectors on a percentage basis.

It is important to note that reporting on a farm basis, does not consider that large farms manage larger volumes of manure. To better account for the greater contribution of large farms, it would have been useful to report adoption of practices based on percentage of manure volume or animal units contributing to manure storage. This would have required more sophisticated analysis, and was not possible under current resources.

Table 2a: Percentage of Farms Answering Questions for Specific Types of Stored Manure, by Province [1]

Province	Farms Answering Questions for Various Types of Stored Manure		
	Only Liquid (%)	Only Solid (%)	Both Liquid and Solid (%)
Newfoundland	[2] x	x	x
PEI	x	0.7	0.1
Nova Scotia	0.2	1.0	0.2
New Brunswick	0.2	0.8	0.2
Atlantic	0.5	2.6	0.6
Quebec	8.5	6.6	5.6
Ontario	4.7	18.0	4.1
Manitoba	0.8	7.3	0.5
Saskatchewan	0.4	14.3	0.4
Alberta	0.6	19.3	1.2
Prairie	1.8	41.0	2.1
B.C.	0.5	2.8	0.6
Canada	16.1	70.9	13.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 2b: Percentage of Farms Answering Questions for Specific Types of Stored Manure, by Ecoregion [1]

Ecoregion	Farms Answering Questions for Various Types of Stored Manure		
	Only Liquid (%)	Only Solid (%)	Both Liquid and Solid (%)
[3] Atlantic Maritime	2.8	4.9	2.3
St. Lawrence Lowlands	6.4	4.7	3.8
Manitoulin-Lake Simcoe-Frontenac	2.4	12.2	2.6
Lake Erie Lowland	1.2	2.7	0.8
Southern Ontario	3.6	14.9	3.5
Boreal Shield	1.0	2.7	0.7
Brown Soil Zone	0.2	6.3	x
Dark Brown Soil Zone	0.4	6.5	0.3
Black Soil Zone	0.4	14.7	0.9
Lake Manitoba Plain	0.3	2.1	0.2
Boreal Plains	0.4	11.8	0.5
Prairie Region	1.8	41.3	2.1
Montane Cordillera	x	1.5	0.1
Pacific Maritime	0.4	0.8	0.5
[3] B.C. Region	0.5	2.3	0.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 2c: Percentage of Farms Answering Questions for Specific Types of Stored Manure, by Livestock Sector [1]

[4] Sector	Farms Answering Questions for Various Types of Stored Manure		
	Only Liquid (%)	Only Solid (%)	Both Liquid and Solid (%)
Dairy	8.2	6.2	12.3
Beef	1.0	58.9	0.5
Pork	6.3	0.6	x
Poultry	0.5	3.7	x
Other	x	1.6	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 2a, 2b, and 2c:

[1] Percent values add up to 100 for all values within each table, and is based on total number of farms answering questions on manure storage. This approach allows one to compare different provinces, ecoregions, or sectors for a specific type of manure being stored (within column) and also compare different types of stored manure for specific provinces, ecoregions, or sectors (within row).

[2] Values with an " x " indicate that data has been suppressed because there are not enough farm records to meet the confidentiality requirements of the Statistics Act. This symbol has the same meaning for all subsequent tables in this report.

[3] The B.C. Region in the ecoregion table does not include the Peace Region. The Atlantic Maritime region includes PEI, New Brunswick, Nova Scotia, and eastern Quebec. These definitions also apply to all subsequent ecoregion tables in this report.

[4] Sector is defined as the type of livestock production that contributes most to gross farm receipts. "Other" includes bison, sheep, goats, mink, horses, emu, ostrich, duck, roosters, etc. These definitions also apply to all subsequent sector tables in this report.

Tables 2a, 2b, and 2c provide an indication of how the dataset is apportioned among different types of stored manure and provinces, ecoregions, or sectors. When considering the results to specific questions throughout this report, it is useful to refer back to these tables to gain a perspective of the relative proportion of farms that are represented by these features. For example, while there may be interesting results for practices involving liquid manure storage in the poultry sector, the significance of these results is diminished by the fact that this subset represents only 0.5% of the total farms storing manure.

Results for all solid manure storage practices are reported first in section D, and then for liquid manure storages in section E. For each practice a series of tables are provided, followed by a listing of "key results", and finally some "comments" which provide some commentary on interpreting the results.

D. Solid Manure Storage Systems

1. Type of Solid Manure Storage

Table 3a: Percentage of Farms Indicating Various Types of Solid Manure Storage Systems, by Province [1]

Province	[2] Barn Bedding Pack (%)	[2] Outside Manure Pack (%)	[2] Outside Pile (%)	[2] Pit Below Building (%)	[3] Pile in Field (%)	[3] Storage Structure (%)
Newfoundland	x	x	x	x	x	x
PEI	55.8	x	59.7	x	x	x
Nova Scotia	31.5	11.5	73.9	x	x	x
New Brunswick	33.4	23.8	70.9	x	x	x
Atlantic	39.0	15.0	68.2	x	x	6.7
Quebec	15.1	18.1	45.2	4.8	2.1	30.6
Ontario	43.3	20.3	63.4	2.3	0.8	5.2
Manitoba	23.5	73.2	38.9	x	x	x
Saskatchewan	23.9	75.4	38.4	x	2.1	x
Alberta	16.8	62.7	46.7	x	2.0	0.7
Prairie	20.5	69.0	42.5	0.5	1.9	0.5
B.C.	17.4	36.0	51.4	x	x	8.2
Canada	26.2	45.4	49.7	1.8	1.7	6.7

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 3b: Percentage of Farms Indicating Various Types of Solid Manure Storage Systems by Sector [1]

Sector	[2] Barn Bedding Pack (%)	[2] Outside Manure Pack (%)	[2] Outside Pile (%)	[2] Pit Below Building (%)	[3] Pile in Field (%)	[3] Storage Structure (%)
Dairy	28.5	17.4	53.5	3.0	1.2	19.3
Beef	25.0	57.0	47.8	1.1	1.9	2.1
Pork	x	32.2	55.0	x	x	x
Poultry	28.4	9.6	52.9	7.9	x	15.4
Other	44.6	31.6	64.0	x	x	7.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 3c: Percentage of Farms Indicating Various Types of Solid Manure Storage Systems by Ecoregion [1]

Ecoregion	[2] Barn Bedding Pack (%)	[2] Outside Manure Pack (%)	[2] Outside Pile (%)	[2] Pit Below Building (%)	[3] Pile in Field (%)	[3] Storage Structure (%)
Atlantic Maritime	8.0	17.1	58.5	4.9	1.8	18.9
St. Lawrence Lowlands	20.2	15.9	47.7	3.0	2.3	27.8
Manitoulin-Lake Simcoe-Frontenac	43.4	19.8	63.6	2.4	x	5.8
Lake Erie Lowland	51.0	13.6	59.5	x	x	3.5
Southern Ontario	44.8	18.6	62.8	2.5	x	5.4
Boreal Shield	25.3	34.4	55.8	3.5	x	11.0
Brown Soil Zone	17.2	66.5	41.4	x	3.5	x
Dark Brown Soil Zone	19.1	73.5	44.5	x	x	x
Black Soil Zone	25.7	70.2	40.9	x	1.2	x
Lake Manitoba Plain	23.9	72.8	35.3	x	x	x
Boreal Plains	15.0	65.3	45.2	x	2.2	x
Prairie Region	20.3	68.9	42.4	0.5	1.9	0.6
Montane Cordillera	13.3	47.4	57.7	x	x	x
Pacific Maritime	26.5	13.5	45.8	x	x	16.8
B.C. Region	19.2	32.2	52.4	3.8	x	9.4

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 3a, 3b, and 3c:

[1] Percent of farms is based on total farms in each province, ecoregion, and sector that indicated having a solid manure storage system. Values for each province, ecoregion, or sector may total greater than 100, since farms can indicate more than one storage system.

[2] Exact wording of these four options in the questionnaire were: "manure on bedding pack in barns", "manure pack in outdoor pens, corrals, or feeding sites", "piled on ground outside barn", and "pit below slats in livestock building".

[3] These two storage systems were identified through data analysis as most common responses provided in an "Other (please specify)" category. "Storage Structure" includes a variety of constructed works such as an open building, shed, lean to, pole structure, etc. which may or may not include a roof.

Key Results

1. In prairie provinces or ecoregions, an outside manure pack was the most common system. This is associated with the beef sector where backgrounding and finishing beef are typically housed in outdoor corrals. Cow / calf operators also use this system for confined feeding.

2. In all other provinces and ecoregions, an outside pile was the most common system. Outside piles are normally used to store manure that was initially deposited in a barn or an outdoor hard surface pad by dairy, beef, or poultry.

3. Barn bedding packs were the third most common system overall, but more common in Ontario and some Atlantic provinces. This system was used to a similar extent in all sectors.

4. Storage structures were more common in Quebec and the St. Lawrence Lowlands ecoregion, with also significant percentages in the Atlantic and Pacific Maritime ecoregions. Storage structures were used more in dairy and poultry, than other sectors.

5. Other analysis not included in above tables shows that, across Canada, 75% of farms with solid manure used only one system to store this manure. About 18.5% used two systems, while the remaining 6.5% used mostly three systems. These results do not vary greatly between provinces, ecoregions, or sectors.

Comments

Different types of storage structures do not inherently mean different levels of environmental impact. This is determined more by specific characteristics of the structure such as the presence of a roof, impermeable pad, or runoff containment. Results of these characteristics are presented in the next sections of this report. The only exception may be "pile in field" which typically would not have some of these specific features.

2. Use of a Concrete or Other Impermeable Pad

Table 4a: Percentage of Farms using a Concrete or Other Impermeable Pad, by Storage System Type

Storage System	Use of Impermeable Pad		
	Yes, all (%)	Yes, some [1] (%)	No (%)
Barn Bedding Pack	59.3	9.7	31.0
Outside Manure Pack	16.6	**3.3**	80.0
Outside Pile	34.5	4.2	61.3
Pit Below Building	80.0	x	19.6
Pile in Field	x	x	97.6
Storage Structure	91.1	x	8.3

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 4b: Percentage of Farms using a Concrete or Other Impermeable Pad, by Province [2]

Province	Use of Impermeable Pad		
	Yes, all (%)	Yes, some [1] (%)	No (%)
Newfoundland	x	x	x
PEI	27.7	27.2	45.2
Nova Scotia	62.3	17.2	20.5
New Brunswick	27.6	19.0	53.4
Atlantic	41.4	20.5	38.1
Quebec	67.0	7.9	25.1
Ontario	65.3	16.7	18.0
Manitoba	10.3	8.9	80.8
Saskatchewan	5.3	8.6	86.1
Alberta	9.2	7.3	83.5
Prairie	8.1	8.0	83.9
B.C.	35.1	6.2	58.7
Canada	34.1	10.7	55.3

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 4c: Percentage of Farms using a Concrete or Other Impermeable Pad, by Ecoregion [2]

Ecoregion	Use of Impermeable Pad		
	Yes, all (%)	Yes, some [1] (%)	No (%)
Atlantic Maritime	53.3	14.8	31.8
St. Lawrence Lowlands	67.2	8.5	24.2
Manitoulin-Lake Simcoe-Frontenac	71.3	15.8	12.9
Lake Erie Lowland	64.9	18.5	16.5
Southern Ontario	70.1	16.3	13.6
Boreal Shield	42.3	14.9	42.7
Brown Soil Zone	5.9	4.8	89.4
Dark Brown Soil Zone	7.0	11.4	81.6
Black Soil Zone	9.3	9.5	81.2
Lake Manitoba Plain	8.8	10.0	81.2
Boreal Plains	8.1	5.4	86.6
Prairie Region	8.1	7.9	84.0
Montane Cordillera	12.8	x	82.7
Pacific Maritime	71.8	9.4	18.8
B.C. Region	39.6	6.8	53.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 4d: Percentage of Farms using a Concrete or Other Impermeable Pad, by Sector [2]

Sector	Use of Impermeable Pad		
	Yes, all (%)	Yes, some [1] (%)	No (%)
Dairy	70.6	11.5	18.0
Beef	20.0	10.5	69.5
Pork	56.6	1.7	41.8
Poultry	68.1	6.2	25.8
Other	44.8	19.9	35.3

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 4a, 4b, 4c, and 4d:

[1] "Yes, some" means for a given farm and structure type, an impermeable pad was used for some structures or possibly only part of that structure. This interpretation also applies to the next two sections on "Use of a Roof or Cover" and "Runoff Containment".

[2] For analysis by province, ecoregion, and sector it was necessary to create a single "impermeable pad" response, where farms indicated more than one storage type. In this case "Yes, all" and "No" were only used where all responses for a given farm were one of these two. All other response types were considered "Yes, some". This same approach was used for the next two sections on "Use of a Roof or Cover" and "Runoff Containment".

Key Results

1. There were large differences in the use of impermeable pads depending on the type of storage system used. Outside piles and piles in the field utilized impermeable pads the least, while storage structures and pits below buildings utilized them the most.

2. At the provincial scale Quebec, Ontario, and Nova Scotia had the highest percentage of farms using impermeable pads, while the prairie provinces utilized these the least.

3. At the ecoregion scale there were similar trends to the provinces. However, for B.C. considerably more use of impermeable pads occurred in the Pacific Maritime region, and much less in the Montane Cordillera region.

4. Use of impermeable pads was greatest within the dairy and poultry sectors, and least with the beef sector.

Comments

1. An impermeable pad is designed to prevent leaching of nutrients and pathogens into groundwater systems below the solid manure storage system. Storages without a constructed impermeable pad are normally located on bare subsoil ground with topsoil removed. In some cases these sites may develop reduced permeability properties over time due to compaction and changes in chemical properties in the subsoil. Therefore, the lack of a constructed impermeable pad does not necessarily indicate an increased risk of leaching.

2. Lack of impermeable pads in the Prairie and Montane Cordillera regions is likely associated mostly with beef production on outside manure packs. The risk of leaching in these regions may be less than other regions, due to considerably lower annual precipitation.

3. Use of a Roof or Cover

Table 5a: Percentage of Farms using a Roof or Cover, by Storage System Type

[1] Storage System	Use of Roof or Cover		
	Yes, all (%)	Yes, some (%)	No (%)
Outside Manure Pack	3.6	7.1	89.3
Outside Pile	3.9	1.3	94.8
Pile in Field	x	x	99.4
Storage Structure	52.0	x	47.5

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Note for Table 1a:

[1] Barn bedding packs and pits below building inherently all have roofs or covers, and this question was not asked for these types of storages. Therefore, all subsequent tables in this section only involve the four storage systems shown in Table 5a.

Table 5b: Percentage of Farms using a Roof or Cover, by Province

Province	Use of Roof or Cover		
	Yes, all (%)	Yes, some (%)	No (%)
Newfoundland	x	x	x
PEI	x	x	90.0
Nova Scotia	x	x	89.4
New Brunswick	x	x	93.7
Atlantic	5.3	3.9	90.8
Quebec	28.4	2.4	69.2
Ontario	7.9	3.5	88.6
Manitoba	1.7	9.0	89.3
Saskatchewan	1.2	6.6	92.1
Alberta	0.9	4.2	94.9
Prairie	1.2	5.9	92.9
B.C.	15.4	5.1	79.5
Canada	7.4	4.7	87.8

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 5c: Percentage of Farms using a Roof or Cover, by Sector

Sector	Use of Roof or Cover		
	Yes, all (%)	Yes, some (%)	No (%)
Dairy	18.5	5.1	76.4
Beef	3.0	4.7	92.3
Pork	x	x	74.7
Poultry	30.9	x	67.2
Other	x	x	88.8

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 5d: Percentage of Farms using a Roof or Cover, by Ecoregion

Ecoregion	Use of Roof or Cover		
	Yes, all (%)	Yes, some (%)	No (%)
Atlantic Maritime	17.4	3.6	79.1
St. Lawrence Lowlands	25.5	1.6	72.9
Manitoulin-Lake Simcoe-Frontenac	9.4	3.7	86.8
Lake Erie Lowland	7.9	x	89.7
Southern Ontario	9.2	3.5	87.3
Boreal Shield	9.4	4.7	85.9
Brown Soil Zone	x	4.5	94.8
Dark Brown Soil Zone	x	5.0	93.5
Black Soil Zone	1.5	8.2	90.3
Lake Manitoba Plain	x	7.2	90.8
Boreal Plains	x	3.8	95.4
Prairie Region	1.2	5.9	93.0
Montane Cordillera	x	x	90.2
Pacific Maritime	36.6	x	56.1
B.C. Region	17.8	5.8	76.4

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Key Results

1. The vast majority of outside manure packs, outside piles, and piles in fields did not have a roof or cover. About half of storage structures did have a roof or cover.

2. In most provinces the vast majority of farms did not use a roof or cover over their solid manure storage system. In Quebec and B.C. the majority was slightly smaller.

3. At the ecoregion scale there were similar trends to the provinces. However, for the Pacific Maritime region a higher percentage (36%) of producers used a roof or cover.

4. For all sectors the majority of producers did not use a roof or cover. However, the use of a roof or cover was more prevalent in the poultry and dairy sectors.

Comments

1. A roof or cover can help reduce nutrient and pathogen losses by eliminating exposure to precipitation which can contribute to increased leaching and runoff. In the absence of a roof or cover these risks may be minimal if the storage system has an impermeable pad and/or runoff containment. This is addressed through some integrated analysis in section D.5.

2. The greatest use of roofs or covers is in the Pacific Maritime region which also receives the most precipitation of any region in Canada, and therefore has the most to gain from implementing this practice.

3. A roof or cover can also be useful when manure is being composted, as it facilitates proper moisture control and equipment trafficability for turning the compost. However, some separate analysis shows that a roof or cover was very minimal on compost systems and essentially the same as non-composted manure storage systems. See section D.7 for more information on manure treatment systems, such as compost.

4. Runoff Containment

Table 6a: Percentage of Farms having Runoff Containment, by Storage System Type

[1] Storage System	Use of Runoff Containment		
	Yes, all (%)	Yes, some (%)	No (%)
Outside Manure Pack	23.8	9.2	67.0
Outside Pile	27.5	6.1	66.4
Pile in Field	13.1	x	83.6
Storage Structure	71.3	x	26.9

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Note for Table 1a:
[1] Barn bedding packs and pits below building inherently are already contained manure storages, and this question was not asked for these types of storages. Therefore, all subsequent tables in this section only involve the four storage systems shown in Table 6a.

Table 6b: Percentage of Farms having Runoff Containment, by Province

Province	Use of Runoff Containment		
	Yes, all (%)	Yes, some (%)	No (%)
Newfoundland	x	x	x
PEI	22.8	x	70.9
Nova Scotia	36.0	17.7	46.3
New Brunswick	22.8	x	67.9
Atlantic	28.2	11.7	60.1
Quebec	57.6	4.1	38.4
Ontario	35.2	9.2	55.6
Manitoba	17.7	10.2	72.1
Saskatchewan	15.5	10.5	74.0
Alberta	17.9	11.4	70.7
Prairie	17.0	10.9	72.1
B.C.	30.4	5.5	64.1
Canada	28.1	9.3	62.5

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 6c: Percentage of Farms having Runoff Containment, by Sector

Sector	Use of Runoff Containment		
	Yes, all (%)	Yes, some (%)	No (%)
Dairy	53.3	9.4	37.3
Beef	19.8	9.5	70.7
Pork	49.9	x	43.7
Poultry	44.5	5.0	50.4
Other	32.6	11.6	55.8

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 6d: Percentage of Farms having Runoff Containment, by Ecoregion

Ecoregion	Use of Runoff Containment		
	Yes, all (%)	Yes, some [1] (%)	No (%)
Atlantic Maritime	44.7	7.5	47.9
St. Lawrence Lowlands	54.3	3.1	42.6
Manitoulin-Lake Simcoe-Frontenac	35.6	9.2	55.2
Lake Erie Lowland	37.4	11.9	50.7
Southern Ontario	35.9	9.7	54.4
Boreal Shield	38.1	9.1	52.8
Brown Soil Zone	18.0	9.4	72.7
Dark Brown Soil Zone	18.8	10.6	70.6
Black Soil Zone	19.0	12.0	69.1
Lake Manitoba Plain	17.8	11.9	70.2
Boreal Plains	13.2	10.3	76.6
Prairie Region	17.1	10.9	72.0
Montane Cordillera	27.4	x	66.8
Pacific Maritime	38.3	x	57.6
B.C. Region	31.8	5.1	63.1

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Key Results

1. The majority of outside manure packs, outside piles, and especially piles in fields did not have runoff containment. However, the majority of farms with constructed storage structures did have runoff containment.

2. Quebec is the only province where a majority of farms had runoff containment for all their solid manure storages. Nova Scotia also had a majority of farms with runoff containment, but some of these only have it for some of their solid manure storages.

3. At the ecoregion scale there were similar trends to the provinces, with the St. Lawrence Lowland being the only ecoregion where a majority of farms had runoff containment for all their solid manure storages.

4. For most sectors at least half of farms had at least some runoff containment, except for beef where over 70% did not.

Comments

Runoff containment is designed to prevent water in contact with manure from flowing out of the storage area, thereby minimizing risk of nutrients and pathogens entering surface water bodies such as streams, rivers, and lakes. Runoff containment may not be necessary if excess water sources are eliminated. This could involve ensuring the manure source is dry enough to not create a leachate, including a roof or cover to prevent rain or snow falling on manure, and diverting upstream surface water flows to prevent run-on into the storage area. Nevertheless, even if some nutrients and pathogens are transported some distance from the manure storage area, this may not cause environmental concerns if this flowing water becomes naturally contained or absorbed in surface soils before entering a surface water body. The next section, D.5, addresses the adoption of multiple practices such as runoff containment and roofs/covers.

5. Adoption of Multiple Practices

Table 7a: Percentage of Farms Utilizing Multiple Practices, by Province

Impermeable Pad	Yes				No			
Runoff Containment	Yes		No		Yes		No	
Roof or Cover	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
Newfoundland	x	x	x	x	x	x	x	20.0
PEI	x	x	x	25.3	x	x	x	40.9
Nova Scotia	x	38.2	x	29.8	x	x	x	13.2
New Brunswick	x	18.7	x	19.1	x	x	x	45.3
Atlantic	5.4	25.1	x	24.8	x	9.3	x	31.6
Quebec	23.5	30.0	6.4	12.6	x	7.9	x	19.1
Ontario	8.1	33.8	2.7	34.7	x	2.2	x	17.9
Manitoba	2.2	6.6	x	8.0	2.2	16.9	5.9	57.8
Saskatchewan	0.9	4.7	x	7.4	1.6	18.8	5.0	61.2
Alberta	1.2	6.6	x	6.4	1.0	20.4	2.3	61.5
Prairie	1.3	5.9	0.5	7.0	1.5	19.2	3.9	60.7
B.C.	6.8	10.5	8.5	10.0	x	16.2	x	42.7
Canada	6.5	16.9	2.3%	15.2	1.0	13.0	2.3	42.7

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 7b: Percentage of Farms Utilizing Multiple Practices, by Ecoregion

Impermeable Pad	Yes				No			
Runoff Containment	Yes		No		Yes		No	
Roof	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
Atlantic Maritime	16.5	26.6	3.9	18.7	x	8.7	x	25.1
St. Lawrence Lowlands	19.4	30.4	6.9	16.2	x	7.6	x	19.2
Manitoulin-Lake Simcoe-Frontenac	10.0	34.3	x	38.5	x	x	x	14.0
Lake Erie Lowland	6.3	40.5	x	28.1	x	x	x	18.7
Southern Ontario	9.4	35.4	2.9	36.7	x	0.4	x	14.8
Boreal Shield	9.2	27.0	x	16.0	x	10.6	x	32.3
Brown Soil Zone	x	5.1	x	4.9	x	20.9	3.9	63.9
Dark Brown Soil Zone	x	8.5	x	7.9	x	19.2	3.9	58.0
Black Soil Zone	1.9	6.4	x	8.1	2.4	20.3	5.0	55.5
Lake Manitoba Plain	x	6.2	x	6.1	x	18.9	x	59.6
Boreal Plains	x	4.2	x	6.4	x	17.3	2.4	67.5
Prairie Region	1.2	5.9	0.5	7.0	1.4	19.3	3.9	60.7
Montane Cordillera	x	x	x	x	x	22.1	x	57.7
Pacific Maritime	14.7	22.0	22.7	18.7	x	x	x	12.1
B.C. Region	8.0	11.8	9.7	10.9	*	14.4	*	39.2

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 7c: Percentage of Farms Utilizing Multiple Practices, by Sector

Impermeable Pad	Yes				No			
Runoff Containment	Yes		No		Yes		No	
Roof	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
Dairy	16.8	38.4	4.5	20.2	x	6.4	1.0	11.7
Beef	2.6	10.3	1.2	13.7	1.0	15.3	2.8	53.0
Pork	x	x	x	x	x	x	x	35.3
Poultry	20.8	21.4	10.7	14.7	x	6.6	x	24.3
Other	x	26.2	x	26.6	x	10.8	x	25.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 7a, 7b, and 7c: The word “Yes” always includes both farms that indicated “Yes, all” and “Yes, some”. These were combined to reduce data suppression. Also, this analysis did not include “barn bedding pack” or “pit below building” storage types, since these are not included in questions regarding runoff containment and roofs or covers.

Key Results

1. The majority of farms with solid manure storages in the beef sector, the prairie provinces / ecoregions, and Montane Cordillera did not use any of the three practices of impermeable pad, runoff containment, or roof / cover.

2. A very small percentage of farms with solid manure storages across Canada utilized all three practices (6.5%), with somewhat higher uptake in the province of Quebec, the St.

Lawrence Lowlands, Atlantic Maritime, and Pacific Maritime ecoregions, and the poultry and dairy sectors.

3. The most common combination of multiple practices was impermeable pads with runoff containment, used more often in provinces and ecoregions from Ontario east and in the Pacific Maritime region of B.C. This combination of practices was also more common in the dairy sector.

Comments

Generally, very low uptake of all three practices suggests room for considerably more adoption. However, the use of all three practices was appropriately greater in regions with higher precipitation and greater need for these practices.

6. Distance to Nearest Surface Water

Table 8a: Percentage of Farms with Solid Manure Storages at Various Distances from Nearest Surface Water (meters), by Storage Type

Storage System	< 30 (%)	30 – 60 (%)	60 – 90 (%)	> 90(%)	No Surface Water (%)
Barn Bedding Pack	4.1	4.7	2.4	54.2	34.6
Outside Manure Pack	3.8	3.6	2.6	66.3	23.6
Outside Pile	2.9	4.0	2.7	56.0	34.5
Pit Below Building	x	x	x	37.3	49.3
Pile in Field	x	x	x	52.5	28.4
Storage Structure	4.9	5.0	4.1	42.7	43.3

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 8b: Percentage of Farms with Solid Manure Storages at Various Distances from Nearest Surface Water (meters), by Province

Province	< 30 (%)	30 – 60 (%)	60 – 90 (%)	> 90(%)	No Surface Water (%)
Newfoundland	x	x	x	x	x
PEI	x	x	x	50.6	46.4
Nova Scotia	x	x	x	55.4	29.7
New Brunswick	x	x	x	51.6	34.6
Atlantic	x	3.3	5.0	52.2	36.9
Quebec	3.3	5.0	1.7	37.9	52.0
Ontario	3.5	3.6	3.0	43.2	46.6
Manitoba	2.7	3.0	2.8	56.3	35.2
Saskatchewan	5.4	4.4	3.8	72.6	13.9
Alberta	2.0	3.0	1.9	74.2	18.9
Prairie	3.3	3.5	2.7	70.4	20.2
B.C.	3.8	3.8	4.2	51.3	36.9
Canada	3.4	3.7	2.8	57.0	33.1

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 8c: Percentage of Farms with Solid Manure Storages at Various Distances from Nearest Surface Water (meters), by Ecoregion

Ecoregion	< 30 (%)	30 – 60 (%)	60 – 90 (%)	> 90 (%)	No Surface Water (%)
Atlantic Maritime	2.6	5.2	4.2	47.1	40.9
St. Lawrence Lowlands	4.1	4.6	x	34.9	55.8
Manitoulin-Lake Simcoe-Frontenac	4.2	3.5	3.1	44.6	44.7
Lake Erie Lowland	x	4.1	4.2	34.1	56.4
Southern Ontario	3.6	3.6	3.3	42.6	46.9
Boreal Shield	x	x	x	48.5	44.4
Brown Soil Zone	3.1	2.4	x	78.6	14.1
Dark Brown Soil Zone	2.6	4.7	2.5	73.9	16.4
Black Soil Zone	4.5	3.4	3.1	69.7	19.3
Lake Manitoba Plain	x	x	x	52.3	38.1
Boreal Plains	2.6	3.3	2.5	69.1	22.5
Prairie Region	3.3	3.5	2.7	70.5	20.0
Montane Cordillera	x	x	x	59.6	28.2
Pacific Maritime	x	x	x	32.1	55.3
B.C. Region	3.9	4.1	4.4	47.0	40.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 8d: Percentage of Farms with Solid Manure Storages at Various Distances from Nearest Surface Water (meters), by Sector

Sector	< 30 (%)	30 – 60 (%)	60 – 90 (%)	> 90(%)	No Surface Water (%)
Dairy	2.6	4.1	2.3	39.7	51.2
Beef	3.7	3.6	2.8	65.1	24.7
Pork	x	x	x	57.9	39.1
Poultry	x	3.1	4.7	20.2	69.0
Other	x	x	x	43.9	46.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Key Results

For all ecoregions, provinces, sectors, and regardless of storage type, the vast majority of farms had either solid manure storages located more than 90 meters from the nearest surface water or had no surface water on their farm.

Comments

As discussed in previous sections the low adoption of runoff containment and roofs or covers may result in offsite movement of nutrients and pathogens via surface water runoff. However, as shown in this section, the relatively large separation distance from the storage to the nearest surface water body may help reduce the impact on downstream water uses if this separation allows for filtering of these substances, through various means, such as grassed waterways and riparian buffers. Nevertheless, some environmental risks may still exist for distances greater than 90 meters and on other downstream land not managed by the farmer that may have surface water.

7. Distance to Nearest Well

Table 9a: Percentage of Farms with Solid Manure Storages at Various Distances from Nearest Well (meters), by Storage Type

Storage System	< 30 (%)	30 – 60 (%)	60 – 90 (%)	> 90(%)	No Wells (%)
Barn Bedding Pack	9.7	12.7	10.8	58.9	7.8
Outside Manure Pack	3.9	7.1	6.0	69.9	13.0
Outside Pile	2.3	8.9	9.7	68.2	10.9
Pit Below Building	16.6	14.8	14.3	41.5	12.9
Pile in Field	x	x	x	80.9	17.6
Storage Structure	5.7	17.8	15.9	47.6	13.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 9b: Percentage of Farms with Solid Manure Storages at Various Distances from Nearest Well (meters), by Province

Province	< 30 (%)	30 – 60 (%)	60 – 90 (%)	> 90(%)	No Wells (%)
Newfoundland	x	x	x	x	x
PEI	x	15.6	12.5	64.5	x
Nova Scotia	x	11.7	11.2	58.7	13.5
New Brunswick	x	13.3	x	61.9	x
Atlantic	4.6	13.3	10.9	61.5	9.6
Quebec	2.6	13.5	12.6	50.7	20.7
Ontario	6.8	16.1	13.3	60.6	3.1
Manitoba	5.4	9.6	6.5	68.8	9.7
Saskatchewan	4.0	5.4	5.5	74.5	10.6
Alberta	1.8	4.1	5.0	74.1	15.0
Prairie	3.2	5.5	5.5	73.3	12.5
B.C.	3.2	5.7	4.9	54.5	31.7
Canada	4.1	9.8	8.8	65.4	11.9

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 9c: Percentage of Farms with Solid Manure Storages at Various Distances from Nearest Well (meters), by Ecoregion

Ecoregion	< 30 (%)	30 – 60 (%)	60 – 90 (%)	> 90(%)	No Wells (%)
Atlantic Maritime	4.0	13.4	10.7	59.5	12.3
St. Lawrence Lowlands	4.1	15.0	16.4	48.6	16.0
Manitoulin-Lake Simcoe-Frontenac	8.0	16.7	12.3	61.8	1.2
Lake Erie Lowland	x	16.2	16.2	53.6	11.1
Southern Ontario	7.0	16.6	13.0	60.2	3.1
Boreal Shield	x	9.5	7.9	60.0	21.1
Brown Soil Zone	2.6	4.1	3.5	68.3	21.5
Dark Brown Soil Zone	2.5	3.6	5.3	68.0	20.5
Black Soil Zone	3.3	6.7	4.5	80.2	5.3
Lake Manitoba Plain	x	9.4	7.4	67.4	12.6
Boreal Plains	3.8	5.0	7.2	69.7	14.3
Prairie Region	3.2	5.5	5.4	72.9	13.0
Montane Cordillera	x	x	x	67.4	22.6
Pacific Maritime	x	9.6	x	46.4	32.4
B.C. Region	3.1	6.5	5.4	58.0	27.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 9d: Percentage of Farms with Solid Manure Storages at Various Distances from Nearest Well (meters), by Sector

Sector	< 30 (%)	30 – 60 (%)	60 – 90 (%)	> 90(%)	No Wells (%)
Dairy	3.9	17.0	13.7	53.1	12.3
Beef	4.3	7.9	6.6	69.6	11.6
Pork	x	x	x	57.7	x
Poultry	4.8	9.2	9.7	61.7	14.6
Other	x	x	18.8	66.2	12.2

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Key Results

For all ecoregions, provinces, sectors, and regardless of storage type, the majority of farms had either solid manure storages located more than 90 meters from the nearest well or had no wells. However, this majority was smaller than for surface water, primarily because a smaller percentage of these farms have no wells, compared to no surface water.

Comments

As discussed in previous sections, the low adoption of impermeable pads, runoff containment and roofs or covers may result in offsite movement of nutrients and pathogens via leaching below the soil surface. However, as shown in this section, the relatively large separation distance from the storage to the nearest wells may help reduce the impact if this separation allows for filtering and dilution of these substances. Nevertheless, some environmental risks may still exist for distances greater than 90 meters and on other downstream users of groundwater.

8. Treatment Practices

Table 10a: Percentage of Farms Utilizing Various Solid Manure Treatment Practices, by Province [1]

Province	[2] Mixed with additives to modify odour (%)	[2] Mixed or turned to accelerate composting (%)	[3] All other practice combinations (%)	None (%)
Newfoundland	x	x	x	x
PEI	x	13.5	x	82.7
Nova Scotia	x	19.7	x	75.5
New Brunswick	x	15.4	x	78.8
Atlantic	2.5	16.4	2.3	78.7
Quebec	2.6	9.9	1.4	86.0
Ontario	3.1	9.6	1.6	85.7
Manitoba	x	43.9	x	54.5
Saskatchewan	x	29.7	0.9	68.9
Alberta	1.0	35.4	1.2	62.4
Prairie	0.7	35.0	1.1	63.2
B.C.	3.4	28.3	x	66.0
Canada	1.8	23.7	1.4	73.1

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 10b: Percentage of Farms Utilizing Various Solid Manure Treatment Practices, by Ecoregion [1]

Ecoregion	[2] Mixed with additives to modify odour (%)	[2] Mixed or turned to accelerate composting (%)	[3] All other practice combinations (%)	None (%)
Atlantic Maritime	x	13.6	1.6	82.4
St. Lawrence Lowlands	2.5	8.9	1.4	87.2
Manitoulin-Lake Simcoe-Frontenac	3.4	7.2	x	87.5
Lake Erie Lowland	3.5	12.8	x	83.2
Southern Ontario	3.4	8.2	1.6	86.7
Boreal Shield	x	18.6	x	78.0
Brown Soil Zone	x	26.0	x	72.6
Dark Brown Soil Zone	x	24.3	1.9	73.8
Black Soil Zone	1.0	41.3	0.8	56.9
Lake Manitoba Plain	x	47.6	x	50.6
Boreal Plains	1.0	34.9	x	63.1
Prairie Region	0.7	34.9	1.1	63.3
Montane Cordillera	x	31.4	x	62.1
Pacific Maritime	x	25.1	x	69.3
B.C. Region	3.6	28.5	2.5	65.3

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 10c: Percentage of Farms Utilizing Various Solid Manure Treatment Practices, by Sector[1]

Sector	[2] Mixed with additives to modify odour (%)	[2] Mixed or turned to accelerate composting (%)	[3] All other practice combinations (%)	None (%)
Dairy	2.3	11.4	1.7	84.7
Beef	1.3	28.0	1.0	69.7
Pork	x	37.8	x	54.0
Poultry	5.7	12.7	4.1	77.6
Other	x	25.1	x	65.8

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 10a, 10b, and 10c:

[1] Value in each province, ecoregion, or sector add up to > 100 since respondents are able to indicate more than one practice.

[2] Values in these columns represent farms that implemented only this practice.

[3] All other practice combinations include “Added to an anaerobic digestion system”, “Other” practices specified by the farmer, and various combinations of multiple practices.

Key Results

1. For all ecoregions, provinces, and sectors the majority of farms did not use any solid manure treatment practices. In all ecoregions, provinces, and sectors the most common treatment practice used was “mixed or turned to accelerate composting”. The percentage of farms using this practice was greater in Western Canada, particularly in Manitoba, and the Black Soil Zone and Lake Manitoba Plain ecoregions. It was also greater for the pork sector.

2. Other treatment practices and use of multiple practices was very minimal throughout the country.

Comments

1. Composting solid manure creates a more homogeneous consistency, and reduces volume/mass, pathogens, and viable weed seeds. It facilitates more uniform land application of manure nutrients, and reduces transportation costs from the farmyard to the field. Some composted manures may be sold off farm for higher value than raw manure. This may also help alleviate potential over-application of manure nutrients on land adjacent to livestock operations.

2. Low adoption of other manure treatment technologies is likely due to insufficient added revenue to offset increased costs.

E. Liquid Manure Storage Systems

1. Number of Liquid Manure Storages

Table 11a: Percentage of Farms Having Various Number of Liquid Manure Storage Systems, by Province

Province	1 (%)	2 (%)	3 (%)	> 3 (%)
Newfoundland	x	x	x	x
PEI	80.7	x	x	x
Nova Scotia	54.3	34.0	x	x
New Brunswick	80.1	x	x	x
Atlantic	68.3	24.6	x	x
Quebec	76.8	16.4	3.9	2.9
Ontario	63.5	22.3	8.1	6.1
Manitoba	74.5	22.9	x	x
Saskatchewan	65.6	29.0	x	x
Alberta	66.9	26.8	x	x
Prairie	69.3	25.9	3.1	x
B.C.	47.6	34.1	13.5	x
Canada	70.3	20.4	5.5	3.8

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 11b: Percentage of Farms Having Various Number of Liquid Manure Storage Systems, by Ecoregion

Ecoregion	1 (%)	2 (%)	3 (%)	> 3 (%)
Atlantic Maritime	78.8	16.6	2.7	x
St. Lawrence Lowlands	73.5	17.9	5.1	3.5
Manitoulin-Lake Simcoe-Frontenac	60.6	24.8	8.4	6.2
Lake Erie Lowland	60.6	21.6	8.8	9.0
Southern Ontario	60.6	23.9	8.5	7.0
Boreal Shield	83.0	11.5	x	x
Brown Soil Zone	40.4	45.6	x	x
Dark Brown Soil Zone	77.2	x	x	x
Black Soil Zone	68.9	28.2	x	x
Lake Manitoba Plain	75.8	19.2	x	x
Boreal Plains	69.4	30.6	x	x
Prairie Region	69.4	25.9	2.9	x
Montane Cordillera	49.6	x	x	x
Pacific Maritime	46.6	35.5	x	x
B.C. Region	47.2	34.4	13.6	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 11c: Percentage of Farms Having Various Number of Liquid Manure Storage Systems, by Sector

Sector	1 (%)	2 (%)	3 (%)	> 3 (%)
Dairy	78.0	15.9	4.0	2.1
Beef	68.6	25.1	x	x
Pork	45.2	34.6	12.2	8.0
Poultry	68.6	20.4	x	x
Other	90.9	x	x	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Key Results

1. For most ecoregions, provinces, and sectors the majority of farms utilized only one liquid manure storage system. The only exceptions were the Pacific Maritime and Brown Soil Zone ecoregions, B.C. province, and pork sector. However, only in the Brown Soil Zone were two systems more common than one.

2. Very few farms utilized three or more liquid manure storage systems, and these tended to occur more in B.C. and Ontario.

Comments

1. Some farms utilize multi-cell lagoon storage systems, where manure from the first lagoon overflows to the second, and sometimes from a second lagoon to a third. The FEMS survey does define what a system means. However, after asking how many systems, it asks specific questions on each system that refer to a single manure storage pit, lagoon or tank. Therefore, for multi-cell lagoons a farmer may have initially indicated a single system, but may have later changed his/her response to more than one system when questions about specific manure storage structures were asked.

2. Farms with more than one liquid manure storage system may be using a multi-cell approach where there is a single manure stream from the barn. However, on some farms these systems may be independent, involving separate manure streams from different barns and livestock.

3. In a multi-cell system there is some natural separation of liquids and thicker slurry-solids. This separation may be used for recycling liquid for barn flushing, managing manure application to land more efficiently, or as a precursor to additional manure treatment.

4. One might assume that farms create additional manure storage systems to accommodate expansion of operation. Under this scenario one could further assume that farms with multiple manure storage systems may be larger farms. While this may be true, there are also other reasons for utilizing multiple systems, as already noted.

5. While questions on characteristics of these systems were asked for up to three of the largest systems on each farm, subsequent data analysis and reporting was only performed on the largest manure storage system due to limited analysis resources. However, these primary systems made up at least 72% of the total systems reported in FEMS, and by definition involve an even greater percentage of the total stored manure due to their larger size. Therefore, the primary systems still represent a large majority of the data involving an even larger majority of the stored liquid manure. One exception to this approach is the final section E.9 on Treatment Practices, which applies to all three liquid manure storage systems.

2. Type of Primary Liquid Manure Storage

Table 12a: Percentage of Farms Indicating Various Types of Liquid Manure Storage System by Province

Province	Earthen lagoon, pit [1] (%)	Below ground pit (outdoor) (%)	Above ground tank (outdoor) (%)	Pit/tank below slats in barn (%)	Other [2] (%)
Newfoundland	x	x	x	x	x
PEI	x	x	x	x	x
Nova Scotia	39.0	26.1	x	x	x
New Brunswick	65.0	x	x	x	x
Atlantic	46.3	24.2	13.5	10.8	x
Quebec	9.6	19.1	65.3	1.6	4.4
Ontario	28.1	27.9	18.0	19.9	6.1
Manitoba	63.0	8.0	16.8	x	x
Saskatchewan	46.6	x	x	x	36.3
Alberta	74.1	x	9.6	x	x
Prairie	64.9	6.7	11.1	7.1	10.2
B.C.	29.5	37.7	13.2	11.3	x
Canada	24.8	21.0	39.7	8.6	5.9

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 12b: Percentage of Farms Indicating Various Types of Liquid Manure Storage System by Ecoregion

Ecoregion	Earthen lagoon, pit [1] (%)	Below ground pit (outdoor) (%)	Above ground tank (outdoor) (%)	Pit/tank below slats in barn (%)	Other [2] (%)
Atlantic Maritime	10.9	24.9	56.4	2.9	5.0
St. Lawrence Lowlands	16.9	16.8	60.4	1.9	4.0
Manitoulin-Lake Simcoe-Frontenac	16.5	29.9	21.2	23.8	8.6
Lake Erie Lowland	22.7	36.7	12.8	24.8	x
Southern Ontario	18.3	31.9	18.8	24.0	7.0
Boreal Shield	46.1	11.3	34.5	x	x
Brown Soil Zone	54.5	x	x	x	x
Dark Brown Soil Zone	77.3	x	x	x	x
Black Soil Zone	69.9	x	x	11.6	*
Lake Manitoba Plain	67.9	x	x	x	x
Boreal Plains	49.8	x	23.3	x	14.7
Prairie Region	64.8	6.7	11.3	6.8	10.4
Montane Cordillera	x	x	x	x	x
Pacific Maritime	26.8	39.8	13.0	13.0	x
B.C. Region	29.3	38.0	13.4	11.4	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 12c: Percentage of Farms Indicating Various Types of Liquid Manure Storage System by Sector

Sector	Earthen lagoon, pit [1] (%)	Below ground pit (outdoor) (%)	Above ground tank (outdoor) (%)	Pit/tank below slats in barn (%)	Other [2] (%)
Dairy	26.3	21.9	41.0	5.4	5.4
Beef	15.6	15.2	35.4	x	23.7
Pork	22.2	19.6	36.7	19.1	x
Poultry	24.4	30.3	25.4	x	x
Other	x	x	67.4	x	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Note for Tables 12a, 12b, and 12c:
[1] The term "Earthen lagoon, pit" assumes that a pit is also made of earthen materials. Both lagoon and pit have similar meanings, but both terms are provided as each may be predominant in different regions.

[2] Other types of structures were mostly "partially above/below ground tanks or pits" and "manure storage buildings". The latter type of structure was mostly likely designed to handle thicker "semi-solid" manure that had a consistency closer to "solid" than "liquid".

Key Results

1. Overall, the most common liquid manure storage systems were above ground tanks, below ground pits, and earthen lagoons. However, considerable differences exist between provinces and ecoregions.
2. Earthen lagoons were most common in New Brunswick, the prairie provinces and ecoregions, and the Boreal Shield. Below ground pits were more common in Ontario and B.C. provinces and ecoregions. Above ground tanks were more common in Quebec, and the Atlantic Maritime, St. Lawrence Lowland and Boreal Shield ecoregions. Pits below slats in barn were found mostly in Ontario province and ecoregions.

3. Storage type differences between sectors were less evident, partly due to significant data suppression.

Comments

1. Different types of storage structures do not inherently mean different levels of environmental impact. This is determined more by specific characteristics of the structure such as the presence of a roof or cover, storage capacity duration, depth, and proximity to sensitive areas such as water courses. Results of these characteristics are presented in the next sections.

2. The FEMS survey also collected information on the volume of storage, and the type of materials used for the floor, walls, and roof or cover. These attributes were not analyzed since their impact on environmental risk is much less certain. For example, environmental risk associated with leakage from a liquid manure storage system is dependent much more on the condition of materials than the type of materials used. One could assume that certain materials have a greater life expectancy than others, and experience leakage later than others. However, the critical issue is whether these systems are managed to maintain their integrity over the long term and this issue was not addressed in FEMS.

3. Depth of Primary Storage

Table 13a: Percentage of Farms Indicating Various Depth Ranges[1] (feet) for Their Primary Liquid Manure Storage System, by Storage System Type

Storage System	< or = 8 (%)	9 to 11 (%)	12 to 13 (%)	> 13 to 16 (%)	> 16 (%)
Earthen lagoon, pit	20.5	15.8	24.0	24.3	15.5
Below ground tank (outside of building)	27.2	22.5	35.7	13.2	x
Above ground tank (outside of building)	20.2	7.7	46.5	20.8	4.8
Pit/tank below slats in building	63.7	28.0	5.1	x	x
Other	39.2	16.6	31.2	10.9	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 13b: Percentage of Farms Indicating Various Depth Ranges[1] (feet) for Their Primary Liquid Manure Storage System, by Sector

Sector	< or = 8 (%)	9 to 11 (%)	12 to 13 (%)	> 13 to 16 (%)	> 16 (%)
Dairy	25.8	15.4	33.1	19.9	5.9
Beef	32.7	19.6	29.8	x	x
Pork	27.7	13.0	39.3	13.3	6.8
Poultry	35.4	20.5	29.6	x	x
Other	x	x	53.9	x	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 13c: Percentage of Farms Indicating Various Depth Ranges[1] (feet) for Their Primary Liquid Manure Storage System, by Province

Province	< or = 8 (%)	9 to 11 (%)	12 to 13 (%)	> 13 to 16 (%)	> 16 (%)
Newfoundland	x	x	x	x	x
PEI	x	x	x	x	x
Nova Scotia	38.2	x	24.9	x	x
New Brunswick	32.6	x	x	x	x
Atlantic	30.8	17.7	30.4	16.6	x
Quebec	22.5	9.9	44.0	21.5	2.1
Ontario	32.7	20.7	29.7	12.7	4.1
Manitoba	23.1	19.5	19.7	22.4	15.2
Saskatchewan	36.5	21.0	x	23.4	12.9
Alberta	20.0	13.1	14.6	13.3	39.1
Prairie	24.1	16.8	14.8	18.3	26.0
B.C.	36.5	29.5	15.2	10.0	x
Canada	26.6	15.0	34.4	17.8	6.1

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 13d: Percentage of Farms Indicating Various Depth Ranges[1] (feet) for Their Primary Liquid Manure Storage System, by Ecoregion

Ecoregion	< or = 8 (%)	9 to 11 (%)	12 to 13 (%)	> 13 to 16 (%)	> 16 (%)
Atlantic Maritime	21.5	13.0	41.7	22.2	1.6
St. Lawrence Lowlands	23.7	9.7	43.1	20.4	3.1
Manitoulin-Lake Simcoe-Frontenac	36.2	23.5	28.4	9.2	x
Lake Erie Lowland	34.4	12.9	34.5	12.8	x
Southern Ontario	35.7	20.5	30.1	10.2	3.5
Boreal Shield	22.0	18.5	31.8	24.1	x
Brown Soil Zone	x	x	x	x	x
Dark Brown Soil Zone	22.7	x	21.8	20.7	x
Black Soil Zone	22.6	14.8	x	15.5	40.8
Lake Manitoba Plain	x	x	28.5	x	x
Boreal Plains	34.3	15.9	11.0	19.1	19.7
Prairie Region	24.0	16.8	14.6	18.4	26.3
Montane Cordillera	x	x	x	x	x
Pacific Maritime	38.9	27.0	15.0	x	x
B.C. Region	36.8	29.3	15.3	x	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Note for Tables 13a, 13b, 13c, and 13d:

[1] Respondents were asked to provide the depth (at the deepest part) in units of their choice. The data was later reclassified to fit the above depth ranges.

Key Results

1. Earthen lagoons or pits and above ground tanks (outdoor) tended to be deeper than other storage types. Pits or tanks below slats in buildings had the shallowest depths.

2. Across Canada, there were a greater percent of farms in the "12 to 13" and "< or = 8", and fewer in the "> 16" foot depth range.

3. For most ecoregions, provinces, and sectors there was a significant distribution of farms in all five depth ranges. However, the following differences are worth noting:

a) The "12 to 13" foot depth range was most common in the province of Quebec and the Atlantic Maritime and St. Lawrence Lowlands ecoregions. This was followed by Atlantic provinces and Ontario, plus southern Ontario and Boreal Shield ecoregions.
b) The "> 16" foot depth range was much more common in the prairie provinces and ecoregions, than other parts of Canada.
c) The "9 to 11" foot depth range was somewhat more common in B.C. and the Pacific Maritime region.
d) Dairy and pork sectors tended to have deeper liquid manure storage systems than beef and poultry.

Comments

1. Greater depth of manure storage systems for some regions and sectors may be associated with larger volume manure storages and larger farm sizes. For example, in prairie regions deeper manure storages may be associated with earthen lagoons (see Tables 12a and 12b) and large pork operations.

2. Deeper manure storage systems may be more environmentally beneficial, provided they are not prone to leakage, for a number of reasons. First, deeper pits may have lower emissions of some gases (eg. ammonia) due to greater volume to surface area ratio and lower biological activity. Secondly, the impact of precipitation in reducing capacity for uncovered storages can be mitigated to some extent by increasing the storage depth. This impact would be greater for straight walled structures than sloping walled structures. On the other hand deeper storages may contribute to increased anaerobic conditions and methane production.

3. Depth of storage for below ground pits may be constrained by subsurface soil materials and depth to water table. It may be difficult to excavate bedrock material. Coarser soil materials (ie. sand and gravel) are much more susceptible to leaching of nutrients into groundwater, but this can be mitigated by ensuring manure storage walls and floor are properly sealed. However, a manure storage normally cannot be deeper than the groundwater table due to the effect of hydrostatic pressure on damaging the structural integrity of storage floor and walls.

4. The FEMS survey also asked producers the volume and surface area of their liquid manure storage(s). Volume is not reported because a significant percentage of respondents did not know this value. Surface area is not reported because the values reported were highly variable. One might expect that surface area would increase as depth increases, particularly for storages with sloping side and end slopes. However, some analysis showed that average surface area did not change greatly with the above depth ranges. Nevertheless, even in this scenario volume to surface area ratio would still increase with depth, so that the second sentence in comment #2 above is still valid.

4. Use of Roof or Cover for Primary Storage

Table 14a: Percentage of Farms Having Various Types of Roof or Cover for Their Primary Liquid Manure Storage System, by Storage Type

Storage System	No Cover [1] (%)	Concrete (%)	Structure with Roof [2] (%)	Straw (%)	All Other [3] (%)
Earthen lagoon, pit	86.6	2.0	1.8	7.3	2.2
Below ground tank (outside of building)	73.6	13.5	7.9	x	2.5
Above ground tank (outside of building)	80.0	5.2	10.9	1.2	2.7
Pit/tank below slats in building	16.7	67.2	10.9	x	x
Other	63.1	x	23.5	8.6	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 14b: Percentage of Farms Having Various Types of Roof or Cover for Their Primary Liquid Manure Storage System, by Province

Province	No Cover [1] (%)	Concrete (%)	Structure with Roof [2] (%)	Straw (%)	All Other [3] (%)
Newfoundland	x	x	x	x	x
PEI	73.0	x	x	x	x
Nova Scotia	75.3	x	x	x	x
New Brunswick	93.4	x	x	x	x
Atlantic	81.9	x	x	x	x
Quebec	76.6	6.2	13.4	1.5	2.3
Ontario	69.1	20.3	3.7	3.8	3.1
Manitoba	74.3	8.7	x	11.5	x
Saskatchewan	74.6	x	x	x	x
Alberta	78.1	9.7	x	x	x
Prairie	76.1	9.7	x	10.4	2.8
B.C.	61.0	18.9	15.9	x	x
Canada	73.8	11.5	8.7	3.3	2.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 14c: Percentage of Farms Having Various Types of Roof or Cover for Their Primary Liquid Manure Storage System, by Sector

Sector	No Cover [1] (%)	Concrete (%)	Structure with Roof [2] (%)	Straw (%)	All Other [3] (%)
Dairy	76.8	7.9	10.4	2.8	2.1
Beef	70.5	13.2	x	x	x
Pork	66.8	21.1	4.4	4.7	2.9
Poultry	53.8	26.6	x	x	x
Other	70.8	x	x	x	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 14d: Percentage of Farms Having Various Types of Roof or Cover for Their Primary Liquid Manure Storage System, by Ecoregion

Ecoregion	No Cover [1] (%)	Concrete (%)	Structure with Roof [2] (%)	Straw (%)	All Other [3] (%)
Atlantic Maritime	75.8	9.0	13.7	x	x
St. Lawrence Lowlands	79.0	4.3	11.3	2.3	3.1
Manitoulin-Lake Simcoe-Frontenac	63.3	24.3	x	x	x
Lake Erie Lowland	65.3	25.8	x	x	x
Southern Ontario	63.9	24.7	4.7	x	2.8
Boreal Shield	81.0	7.2	7.8	x	x
Brown Soil Zone	84.3	x	x	x	x
Dark Brown Soil Zone	75.4	x	x	x	x
Black Soil Zone	78.6	11.2	x	x	x
Lake Manitoba Plain	70.1	x	x	x	x
Boreal Plains	74.2	12.5	x	x	x
Prairie Region	76.1	9.3	x	10.6	x
Montane Cordillera	73.3	x	x	x	x
Pacific Maritime	58.4	18.5	18.5	x	x
B.C. Region	61.1	19.1	16.1	x	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 14a, 14b, 14c, and 14d:

[1] "No cover" includes two responses "no cover" and "crust". The latter is considered a naturally occurring feature of most liquid systems where agitation is delayed for a considerable period of time. However, the number of "crust" responses was surprisingly low. One reason for this suspected "under reporting" may be that a crust is not an actively managed cover and may vary in thickness both spatially and temporarily within one system. Therefore, even though a crust may have impacts on some gaseous emissions (eg. ammonia) it was decided to combine "crust" with "no cover", meaning no actively managed cover.

[2] "Structure with Roof" was not listed as a choice, but rather created as a separate category during data analysis from numerous entries in the "Other" group. Most often these structures support a roof on poles with no walls or only a partial wall.

[3] "All other" types were combined together due to low response rate. These included "tarp", "lid", "geomembrane", and responses from the "other" group not recoded to "structure with roof".

Key Results

1. For all storage types, except "pit/tank below slats in building", a large majority of farms had no cover. For this exception the majority of manure storages had a concrete cover, which likely often also functions as a floor in a livestock barn. As expected, below ground tanks relied more on concrete covers, while above ground tanks used a roof structure. Earthen lagoons were covered the least, but used straw more often than other storage types.

2. For almost all ecoregions, provinces, and sectors a large majority of primary liquid manure structures had no roof or cover, although many of these would have a crust for a period of time prior to agitation.

3. Concrete covers were used by about 20 to 25% of farms with liquid manure storage in Ontario and B.C., the Pacific Maritime and southern Ontario ecoregions, and poultry and pork sectors.

4. Structures with roofs were used by about 10 to 18% of farms in Quebec and B.C., the Atlantic Maritime, St. Lawrence Lowlands, and Pacific Maritime ecoregions, and the dairy sector.

5. Straw was used by about 10% of farms in the prairies.

Comments

1. The environmental impact of different types of covers likely varies considerably as follows:

   a) Concrete: likely keeps out precipitation, provided outdoor sections drain away from pit openings, may help reduce some gaseous emissions
   b) Structure with Roof: keeps out precipitation, but may have little impact on gaseous emissions if airflow not impeded.
   c) Straw: Likely reduces some gaseous emission, but does not keep out precipitation

2. The trend for "structures with roofs" to be more common in regions with higher precipitation, is expected where the primary economic benefit is reducing water volume and subsequent land application costs.

5. Storage Capacity (Months) for Primary Storage

Table 15a: Percentage of Farms Indicating Various Storage Capacity Ranges[1] (months) for Their Primary Liquid Manure Storage System, by Storage Type

Storage System	< 6 (%)	6 to < 9 (%)	9 to < 12 (%)	12 (%)	> 12 (%)
Earthen lagoon, pit	5.2	30.3	17.8	29.3	17.4
Below ground tank (outside of building)	13.3	35.1	22.9	22.9	5.8
Above ground tank (outside of building)	2.6	29.8	31.9	28.6	7.1
Pit/tank below slats in building	24.1	36.5	10.2	16.5	12.7
Other	18.2	33.8	6.7	35.5	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 15b: Percentage of Farms Indicating Various Storage Capacity Ranges[1] (months) for Their Primary Liquid Manure Storage System, by Sector

Sector	< 6 (%)	6 to <9 (%)	9 to < 12 (%)	> or = 12 (%)
Dairy	8.3	31.2	24.8	35.7
Beef	12.0	23.2	10.2	54.6
Pork	7.2	35.4	22.2	35.2
Poultry	x	40.8	x	41.1
Other	x	x	x	54.1

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 15c: Percentage of Farms Indicating Various Storage Capacity Ranges[1] (months) for Their Primary Liquid Manure Storage System, by Province

Province	< 6 (%)	6 to <9 (%)	9 to < 12 (%)	> or = 12 (%)
Newfoundland	x	x	x	x
PEI	x	57.6	x	x
Nova Scotia	x	59.5	x	x
New Brunswick	x	50.0	x	x
Atlantic	14.2	56.3	14.5	15.0
Quebec	1.5	26.5	33.0	38.9
Ontario	9.6	40.5	15.9	34.1
Manitoba	9.3	20.4	x	68.1
Saskatchewan	31.3	27.5	x	38.4
Alberta	15.4	23.8	22.5	38.3
Prairie	16.2	23.3	11.7	48.8
B.C.	48.7	34.8	x	11.2
Canada	8.3	31.9	23.1	36.7

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 15d: Percentage of Farms Indicating Various Storage Capacity Ranges[1] (months) for Their Primary Liquid Manure Storage System, by Ecoregion

Ecoregion	< 6 (%)	6 to <9 (%)	9 to < 12 (%)	> or = 12 (%)
Atlantic Maritime	4.1	37.6	29.1	29.2
St. Lawrence Lowlands	1.3	25.2	31.1	42.4
Manitoulin-Lake Simcoe-Frontenac	12.7	43.0	16.2	28.1
Lake Erie Lowland	6.3	43.8	10.4	39.5
Southern Ontario	10.9	43.3	14.6	31.3
Boreal Shield	7.2	23.7	30.5	38.6
Brown Soil Zone	x	x	x	x
Dark Brown Soil Zone	x	x	x	42.3
Black Soil Zone	19.3	20.1	20.0	40.5
Lake Manitoba Plain	x	13.9	x	75.8
Boreal Plains	15.6	25.2	x	55.5
Prairie Region	16.0	23.6	11.9	48.6
Montane Cordillera	x	x	x	x
Pacific Maritime	53.1	35.5	x	x
B.C. Region	49.1	34.6	x	10.8

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 15a, 15b, 15c, and 15d: [1] Respondents were asked to provide the length of storage capacity in units of their choice. The data was later reclassified to fit the above month ranges.

Key Results

1. Length of storage capacity varied considerably for each storage type and there appeared to be only minor differences in the distribution of farms when comparing storage capacities and storage types. Nevertheless, earthen lagoons and above ground tanks tended to have greater capacity, than below ground tanks and pits below slats in buildings.

2. Length of storage capacity varied considerably between provinces and ecoregions, and not as much between sectors. Overall, "> or = 12" and "6 to < 9" months were the most common storage lengths. The following specifics are worth noting:

a) < 6 months storage was most common only in B.C. and the Pacific Maritime ecoregion.
b) 6 to < 9 months storage was most common in the Atlantic provinces and Ontario, and the Atlantic Maritime and southern Ontario ecoregions.
c) > or = 12 months storage was most common in the prairie provinces and ecoregions, as well as the Quebec and the St. Lawrence Lowlands.

Comments

1. As a general rule it is recommended that farms have enough storage capacity to not have to land apply manure during the dormant season when crops are not taking up nutrients. The length of this dormant season varies considerably across Canada from < 6 months in the Pacific Maritime region to up to 9 months in northern ecoregions.

2. The recommended storage capacity is also impacted by the types of crops that are grown. For example, for most spring seeded annual crops a single manure application in spring is optimal to best utilize nutrients. However, for perennial forages that may be harvested at various times in the growing season and for cover crops grown after annual crops, additional manure applications throughout summer or early fall may be acceptable. Farms that are able to apply manure in different seasons do not require as much storage capacity.

3. While B.C. and the Pacific Maritime ecoregion have the highest percentage of farms with < 6 months of storage capacity, this region also has the longest growing season. Furthermore, in this region a considerable percentage of liquid manure systems are associated with dairy farms that grow perennial forages and cover crops. Therefore, these farms may be able to manage manure sustainably with less storage capacity than other in other regions.

4. One potentially negative impact of longer storage times is increased methane production, due to development of anaerobic conditions. If possible, manure storages should be completely emptied at least once per year.

6. Adoption of Multiple Practices

Table 16a: Percentage of Farms Adopting Multiple Practices for Liquid Manure Storages

Roof or Cover [1]	Storage Capacity [2]	Depth Range [3]	Farms
(Yes/No)	(months)	(feet)	(%)
No	< 9	<12	11.7
		12 to 13	9.4
		> 13	6.6
	9 to < 12	<12	4.9
		12 to 13	8.2
		> 13	6.1
	> or = 12	<12	8.5
		12 to 13	11.7
		> 13	9.2
Yes	< 9	<12	9.4
		12 to 13	2.1
		> 13	1.1
	9 to < 12	<12	2.4
		12 to 13	1.3
		> 13	x
	> or = 12	<12	4.5
		12 to 13	1.8
		> 13	0.5
		Total	100

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 16a, 16b, and 16c:

[1] For this analysis "No roof or cover" also includes crust or straw, since these also allow precipitation entry, and are thus more comparable with storage capacity and depth range.

[2] For this analysis the number of storage capacity classes was reduced from 4 to 3 to minimize data suppression.

[3] For this analysis the number of depth range classes was reduced from 5 to 3 to minimize data suppression.

Table 16b: Percentage of Farms Adopting Multiple Practices [4] for Liquid Manure Storages, by Rolled Up Ecoregion [5]

Roof or Cover	Storage Capacity	Depth Range	Atlantic	St. Lawrence Lowlands	Southern Ontario	Boreal Shield	Western Canada
(Yes/No)	(months)	(feet)	(%)	(%)	(%)	(%)	(%)
All Responses	< 9	<12	17.6	10.7	34.9	14.6	29.7
		12 to 13	15.2	11.2	14.5	8.6	4.9
		> 13	9.2	4.6	5.4	7.9	15.8
	9 to < 12	<12	8.8	10.4	4.8	8.8	2.7
		12 to 13	11.1	13.1	7.5	11.9	x
		> 13	8.5	7.6	x	10.4	6.3
	> or = 12	<12	8.2	11.9	17.3	15.6	13.4
		12 to 13	15.3	19.5	7.4	11.6	8.3
		> 13	6.0	10.9	5.8	10.6	16.9
		Total	100.0	100.0	100.0	100.0	100.0
No	< 9	All Responses	30.8	20.4	32.5	22.8	34.7
	9 to < 12		21.6	26.1	12.6	26.1	9.0
	> or = 12		23.1	34.2	21.6	32.7	36.5
Yes	< 9		11.2	6.2	22.3	8.3	15.7
	9 to < 12		6.8	5.0	x	x	x
	> or = 12		6.5	8.1	8.9	x	x
		Total	100.0	100.0	100.0	100.0	100.0
No	All Responses	<12	21.5	22.7	28.1	29.5	28.5
		12 to 13	33.5	36.4	27.2	25.6	13.6
		> 13	20.4	21.6	11.4	26.6	38.0
Yes		<12	13.2	10.2	28.8	9.5	17.3
		12 to 13	8.1	7.5	x	x	x
		> 13	3.3	x	x	x	x
		Total	100.0	100.0	100.0	100.0	100.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Note: [4] To avoid excessive data suppression it was necessary to compare only two practices at one time. This note also applies to Table 16c.

[5] Due to small sample size it was not possible to report for most individual ecoregions, but rather primarily rolled up ecoregions. These rolled up ecoregions are the same as previous tables, except the prairies are further combined with B.C. to form "Western Canada".

Table 16c: Percentage of Farms Adopting Multiple Practices for Liquid Manure Storages, by Sector[6]

Roof or Cover	Storage Capacity	Depth Range	Dairy	Pork
(Yes/No)	(months)	(feet)	(%)	(%)
All Responses	< 9	<12	20.5	22.1
		12 to 13	11.7	12.8
		> 13	7.5	7.8
	9 to < 12	<12	9.2	3.9
		12 to 13	8.9	12.6
		> 13	7.1	5.5
	> or = 12	<12	11.5	14.4
		12 to 13	12.5	14.0
		> 13	11.1	6.8
		Total	100.0	100.0
No	< 9	All Responses	28.6	26.8
	9 to < 12		20.4	18.9
	> or = 12		29.6	26.3
Yes	< 9		11.1	15.9
	9 to < 12		4.8	x
	> or = 12		5.5	9.0
		Total	100.0	100.0
No	All Responses	<12	27.1	17.9
		12 to 13	27.7	35.8
		> 13	23.7	18.3
Yes		<12	14.1	22.6
		12 to 13	5.4	3.6
		> 13	2.0	x
		Total	100.0	100.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Note: [4] Due to small sample size it was only possible to report for two sectors, dairy and pork.

Key Results

1. At the national scale (ie. Table 16a)
    a) there was a tendency for storages with roofs or covers to have shallower depths and less storage capacity, compared to storages with no roofs or covers.
    b) There was also a trend toward deeper manure storages as storage capacity increases from < 9 months to > 9 months. However, this trend was observed primarily for

storages with no roof or cover.

2. At the rolled up ecoregion scale (ie. Table 16b)
    a) The trend toward deeper manure storages as storage capacity increases from < 9 months to > 9 months, appeared in all ecoregion groups, as shown in the first part of Table 16b.
    b) The tendency for storages with roofs or covers to have less storage capacity, compared to storages with no roofs or covers, appeared to occur in all ecoregion groups, as shown in the second part of Table 16b. However, this assessment is constrained somewhat by data suppression.
    c) The tendency for storages with roofs or covers to have shallower depths, compared to storages with no roofs or covers, appeared to occur in all ecoregion groups, as shown in the third part of Table 16b. However, this assessment is constrained somewhat by data suppression.

3. At the sector scale (ie. Table 16c)
    a) The trend toward deeper manure storages as storage capacity increases from < 9 months to > 9 months, appeared for both dairy and pork, as shown in the first part of Table 16c.
    b) The tendency for storages with roofs or covers to have less storage capacity, compared to storages with no roofs or covers, appeared to occur for both dairy and pork, as shown in the second part of Table 16c.
    c) The tendency for storages with roofs or covers to have shallower depths, compared to storages with no roofs or covers, appeared to occur for both dairy and pork, as shown in the third part of Table 16c.

Comments

1. The trend toward deeper manure storages as storage capacity increases seems intuitive, as depth is a key contributor to storage capacity.

2. The most obvious reason for reduced storage capacity with a roof or cover, may be related to the prohibitive cost or feasibility of constructing a roof for large storages, particularly those with large surface area. Indeed, additional analysis shows that the average surface area of storages with roofs or covers is just over half the surface area of storages without a roof or cover.

3. The trend for storages with roofs or covers to have shallower depths, may be related to depth constraints. For example, storages with roofs or covers are more prevalent in regions with higher precipitation, where shallower water tables might also be more prevalent.

4. The above trends may also be a reflection of design requirements of manure storages. For example, in many provinces producers must design manure storages to achieve minimum storage capacity. For storages without a roof or cover this capacity must include a specified precipitation amount based on the probability of occurrence of storm events of a certain magnitude. With a roof, less storage capacity is required as precipitation inputs are eliminated. Without a roof, increased depth can also reduce the impact of precipitation inputs.

7. Distance to Nearest Surface Water for Primary Storage

Table 17a: Percentage of Farms with Liquid Manure Storages at Various Distances from Nearest Surface Water (meters), by Storage Type

Storage System	< 30 (%)	30 to 60 (%)	60 to 90 (%)	> 90 (%)	No Surface Water (%)
Earthen lagoon, pit	2.8	3.7	2.3	39.4	51.8
Below ground tank (outside of building)	2.2	4.4	2.9	31.4	59.0
Above ground tank (outside of building)	6.2	4.5	2.4	30.1	56.9
Pit/tank below slats in building	4.4	6.7	x	33.4	54.2
Other	x	x	x	50.0	40.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 17b: Percentage of Farms with Liquid Manure Storages at Various Distances from Nearest Surface Water (meters), by Province

Province	< 30 (%)	30 to 60 (%)	60 to 90 (%)	> 90 (%)	No Surface Water (%)
Newfoundland	x	x	x	x	x
PEI	x	x	x	x	59.5
Nova Scotia	x	x	x	48.8	24.9
New Brunswick	x	x	x	45.7	33.9
Atlantic	x	x	x	44.2	36.4
Quebec	4.5	5.4	2.0	30.7	57.5
Ontario	3.5	3.8	2.1	33.7	56.9
Manitoba	x	x	x	37.4	52.8
Saskatchewan	x	x	x	44.3	50.5
Alberta	x	x	x	52.5	38.3
Prairie	3.9	x	x	45.7	45.7
B.C.	x	x	x	30.6	56.0
Canada	4.3	4.5	2.3	34.1	54.9

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 17c: Percentage of Farms with Liquid Manure Storages at Various Distances from Nearest Surface Water (meters), by Sector

Sector	< 30 (%)	30 to 60 (%)	60 to 90 (%)	> 90 (%)	No Surface Water (%)
Dairy	4.7	4.7	2.0	36.4	52.2
Beef	x	x	x	39.5	44.7
Pork	2.2	3.5	2.7	25.6	66.0
Poultry	x	x	x	28.7	56.5
Other	x	x	x	x	45.4

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 17d: Percentage of Farms with Liquid Manure Storages at Various Distances from Nearest Surface Water (meters), by Ecoregion

Ecoregion	< 30 (%)	30 to 60 (%)	60 to 90 (%)	> 90 (%)	No Surface Water (%)
Atlantic Maritime	6.4	7.6	4.8	38.5	42.7
St. Lawrence Lowlands	4.6	3.7	x	28.6	61.9
Manitoulin-Lake Simcoe-Frontenac	x	x	x	32.5	60.1
Lake Erie Lowland	x	x	x	34.1	54.0
Southern Ontario	x	3.7	2.3	33.0	58.3
Boreal Shield	x	8.1	x	34.3	55.2
Brown Soil Zone	x	x	x	56.2	x
Dark Brown Soil Zone	x	x	x	49.0	43.6
Black Soil Zone	x	x	x	49.0	46.5
Lake Manitoba Plain	x	x	x	45.3	44.3
Boreal Plains	x	x	x	35.7	50.9
Prairie Region	3.9	x	x	45.7	45.9
Montane Cordillera	x	x	x	x	x
Pacific Maritime	x	x	x	27.2	59.7
B.C. Region	*	*	*	30.9	55.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Key Results

For virtually all ecoregions, provinces, sectors, and regardless of storage type, a large majority of farms had either liquid manure storages located more than 90 meters from the nearest surface water or had no surface water.

Comments

While the potential exists for liquid manure storages to overflow, this virtually never occurs, as farmers will pump and land apply manure before storages exceed full supply level. Therefore, offsite movement of nutrients and pathogens via surface runoff is very rare, unlike some solid manure storages. The primary risk of offsite movement of nutrients and pathogens from liquid manure storages is from leakage from below ground walls or floors, and then leaching into groundwater. This could impact surface water, if shallow groundwater aquifers discharged into

surface water. The FEMS survey does not address leakage risk. Nevertheless, most jurisdictions require adherence to standards during construction of liquid manure storages to prevent leakage. Therefore, the risk of surface water impacts is likely relatively low due to low risk of leakage and significant separation distances from surface water.

8. Distance to Nearest Well for Primary Storage

Table 18a: Percentage of Farms with Liquid Manure Storages at Various Distances from Nearest Well (meters), by Storage Type

Storage System	< 30 (%)	30 to 60 (%)	60 to 90 (%)	> 90 (%)	No Wells (%)
Earthen lagoon, pit	x	8.5	13.3	58.9	17.9
Below ground tank (outside of building)	2.2	11.6	19.8	54.6	11.8
Above ground tank (outside of building)	2.6	11.3	18.5	54.0	13.6
Pit/tank below slats in building	12.7	24.4	19.2	31.5	12.1
Other	x	x	10.2	72.7	7.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 18b: Percentage of Farms with Liquid Manure Storages at Various Distances from Nearest Well (meters), by Province

Province	< 30 (%)	30 to 60 (%)	60 to 90 (%)	> 90 (%)	No Wells (%)
Newfoundland	x	x	x	x	x
PEI	x	x	x	55.6	x
Nova Scotia	x	x	x	51.4	x
New Brunswick	x	x	33.4	41.6	x
Atlantic	x	13.5	23.3	49.8	x
Quebec	2.2	11.4	18.3	50.9	17.1
Ontario	5.2	14.7	19.8	56.3	4.0
Manitoba	x	x	10.9	69.1	17.3
Saskatchewan	x	x	x	82.7	x
Alberta	x	x	x	62.8	22.5
Prairie	x	3.8	6.3	68.9	18.8
B.C.	x	x	11.7	38.4	40.0
Canada	3.3	11.4	17.1	54.5	13.8

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 18c: Percentage of Farms with Liquid Manure Storages at Various Distances from Nearest Well (meters), by Sector

Sector	< 30 (%)	30 to 60 (%)	60 to 90 (%)	> 90 (%)	No Wells (%)
Dairy	2.6	11.7	17.0	53.9	14.8
Beef	x	7.7	18.9	53.9	14.0
Pork	3.8	11.4	17.2	56.4	11.2
Poultry	x	x	21.0	46.9	x
Other	x	x	x	75.1	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 18d: Percentage of Farms with Liquid Manure Storages at Various Distances from Nearest Well (meters), by Ecoregion

Ecoregion	< 30 (%)	30 to 60 (%)	60 to 90 (%)	> 90 (%)	No Wells (%)
Atlantic Maritime	3.8	14.9	13.6	59.8	7.9
St. Lawrence Lowlands	2.4	10.8	22.3	48.7	15.7
Manitoulin-Lake Simcoe-Frontenac	x	16.4	21.2	54.7	2.4
Lake Erie Lowland	5.9	13.0	14.8	57.4	8.9
Southern Ontario	5.5	15.4	19.3	55.5	4.3
Boreal Shield	x	6.1	14.6	45.7	32.2
Brown Soil Zone	x	x	x	75.4	x
Dark Brown Soil Zone	x	x	x	62.4	35.2
Black Soil Zone	x	x	x	79.3	x
Lake Manitoba Plain	x	x	x	59.7	32.4
Boreal Plains	x	x	x	65.8	x
Prairie Region	x	x	6.3	69.4	18.3
Montane Cordillera	x	x	x	x	x
Pacific Maritime	x	x	x	36.8	40.6
B.C. Region	x	x	11.4	38.8	39.9

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Key Results

1. For almost all storage types, ecoregions, provinces, and sectors, the majority of farms had either liquid manure storages located more than 90 meters from the nearest well or had no wells. However, this majority was smaller than for surface water, primarily because a smaller percentage of these farms had no wells, compared to no surface water.

2. The percent of farms with “Pit/tank below slats in building” located within 60 meters of a well, was higher than other storage types.

3. The percent of farms with liquid manure storages within 90 meters of a well was higher in Ontario, Quebec, and Atlantic provinces / ecoregions.

Comments

1. As described near the end of section E.7, the risk of offsite movement of nutrients and pathogens from liquid manure storages from leakage and leaching into groundwater is likely relatively low. Arguably, the risk of leakage may be greater with earthen lagoons/pits, than other storage types utilizing other more resilient materials such as concrete and steel. However, earthen storages are most common in the prairie region where separation distances to the nearest well are greatest.

2. Shorter distances to wells in non-prairie regions may be a reflection of smaller farm land areas and smaller farm yards.

3. Shorter distances to wells for "Pits/tanks below slats in building" may also be related to smaller farm yard area, where there is limited space outside the barn to construct a manure storage system. One might also speculate that below barn storages may be more robust against leakage, due to their added function of providing a foundation for the building on top.

4. While not related to manure management, higher incidence of "no wells" in some provinces and ecoregions is an indication of farms that are dependent on a survey waterbody or a municipal water source for livestock water supply.

9. Treatment Practices

Table 19a: Percentage of Farms Utilizing Various Liquid Manure Treatment Practices, by Sector [1]

Sector	Aerated or agitated (%)	Mixed with additives to modify odour, pH or nutrient content (%)	[2] Mixed or turned to accelerate composting (%)	Processed to separate liquid from solid (%)	[3] Other Practices (%)	None (%)
Dairy	47.4	5.7	5.5	4.9	1.6	49.2
Beef	44.5	x	16.0	x	9.4	46.8
Pork	39.5	9.5	x	x	2.0	55.8
Poultry	55.0	x	x	x	x	32.8
Other	x	x	x	x	x	75.2

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 19b: Percentage of Farms Utilizing Various Liquid Manure Treatment Practices, by Province[1]

Province	Aerated or agitated (%)	Mixed with additives to modify odour, pH or nutrient content (%)	[2] Mixed or turned to accelerate composting (%)	Processed to separate liquid from solid (%)	[3] Other Practices (%)	None (%)
Newfoundland	x	x	x	x	x	41.8
PEI	x	x	x	x	x	39.6
Nova Scotia	59.8	x	x	x	x	42.7
New Brunswick	46.7	x	x	x	x	58.4
Atlantic	52.7	x	x	x	x	47.0
Quebec	41.6	2.8	3.9	6.1	x	52.5
Ontario	46.2	9.6	3.9	x	2.1	51.1
Manitoba	42.0	x	x	x	x	49.6
Saskatchewan	33.6	x	x	x	x	60.8
Alberta	60.8	18.0	17.5	x	x	43.7
Prairie	49.0	12.7	11.7	x	9.3	49.1
B.C.	68.3	9.1	x	x	x	28.8
Canada	45.4	6.6	5.3	3.8	2.3	50.5

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 19c: Percentage of Farms Utilizing Various Liquid Manure Treatment Practices, by Ecoregion [1]

Ecoregion	Aerated or agitated (%)	Mixed with additives to modify odour, pH or nutrient content (%)	[2] Mixed or turned to accelerate composting (%)	Processed to separate liquid from solid (%)	[3] Other Practices (%)	None (%)
Atlantic Maritime	44.1	x	5.4	5.7	x	52.2
St. Lawrence Lowlands	42.9	2.9	3.8	5.8	x	51.5
Manitoulin-Lake Simcoe-Frontenac	46.1	9.8	x	x	x	50.1
Lake Erie Lowland	39.6	12.9	x	x	x	58.4
Southern Ontario	44.2	10.7	3.7	x	2.1	52.5
Boreal Shield	46.1	x	x	x	x	48.4
Brown Soil Zone	x	x	x	x	x	57.9
Dark Brown Soil Zone	62.9	x	x	x	x	37.1
Black Soil Zone	45.1	17.2	x	x	x	54.0
Lake Manitoba Plain	43.4	x	x	x	x	53.8
Boreal Plains	42.2	x	14.0	x	10.2	46.4
Prairie Region	48.9	13.0	12.0	x	9.6	49.1
Montane Cordillera	50.0	x	x	x	x	x
Pacific Maritime	73.3	x	x	x	x	29.5
B.C. Region	68.9	x	9.3	x	x	28.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 19a, 19b, and 19c:

[1] Values for each province, ecoregion, or sector add up to > 100 since respondents are able to indicate more than one practice.

[2] This practice is possibly only used for thicker semi-solid manure that is too thick for agitation and pumping.

[3] Other practices include one or more of the following:

- Filtered through a marsh or constructed wetland
- Digested in an anaerobic system
- Methane capture
- Dried
- Other, specified by producer

Key Results

1. Across Canada about half of farms did not use any treatment practice, almost half "aerated or agitated", and a very small percentage used other treatment practices.

2. Higher rates of "aerated or agitated" were found in the following groups:
    a) Provinces: B.C., Alberta, and Nova Scotia
    b) Ecoregions: Pacific Maritime and Dark Brown Soil Zone

3. Other treatment practices occurred to varying degrees in various provinces, ecoregions, and sectors but it is inappropriate to make statements about differences since many of these data are suppressed.

Comments

1. Without agitation fine manure solids tend to settle to the bottom of the storage, while coarse solids associated with straw/sawdust bedding or waste feed float to the surface to form a crust. Agitation prior to land application is a strongly recommended practice for liquid manure, to ensure a consistent, uniform nutrient content during the storage emptying and land application process.

For liquid manure systems with low solids content, it may be possible to agitate less than once per year and still remove all manure via pumping. Thus one could speculate that at least some farms that reported no agitation may agitate in a future year. However, in the absence of agitation eventually solids have to be removed through methods other than pumping, which could typically involve a bucket loader or scraper.

2. Storages that are not agitated may experience higher methane emissions.

3. Low adoption of other manure treatment technologies is likely due to insufficient added revenue to offset increased costs.