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Selecting and Siting Poultry and Livestock Manure Storage Structures on Farms

Authored by Jactone Arogo Ogejo, Extension Specialist,
Biological Systems Engineering, Virginia Tech

Introduction

If you raise livestock (beef cattle, dairy cows, goats, sheep, horses, alpacas, e.t.c.) or poultry (broiler chickens, layers, turkey) for income or a hobby, you will have to deal with the manure they produce. The amount of manure produced by the birds or animals you keep depends on their type, age, size, and diet. Tables 1 and 2 present the manure characteristics of various animal types, compiled by the American Society of Agricultural and Biological Engineers, that can be used to assist in planning and designing systems to handle, treat, and use manure if values for local farms are not available.

Manure storage is part of the nutrient management plan on properties where animals and/or poultry are raised. Manure should be considered a resource – not a waste to be discarded. Manure contains valuable organic matter and nutrients that can be used as a fertilizer and/or to produce energy. Manure will accumulate quickly and must be properly managed to minimize the potential for causing nuisance from odors and contamination of surface water and groundwater if entrained in runoff during rainfall events. Manure storage allows a strategic approach to manure application by providing livestock and poultry owners the flexibility for scheduling application or use that takes advantage of the resources in the manure. This publication presents some guidelines to consider for selecting and locating manure storage structures on livestock and poultry farms.

Table 1. Estimated typical manure characteristics as excreted by meat-producing livestock and poultry

Animal type and production grouping	Total manure[1]		Moisture[2]	Total solids	Volatile solids	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Assumed finishing time (days)
	lb/f-a	cu. ft	% wet basis	Pounds per finished animal (lb/f-a)					
Beef									
Finishing cattle	9,800	160	92	780	640	55	7.3	38	153
Swine									
Nursery pig (27.5 lb)	87	1.4	90	10	8.7	0.91	0.15	0.35	36
Grow-finish (154 lb)	1,200	20	90	120	99	10	1.7	4.4	120
Poultry									
Broiler	11	0.17	74h	2.8	2.1	0.12	0.035	0.068	48
Male turkey (toms)	78	1.3	74	20	16	1.2	0.36	0.57	133
Female turkey (hens)	38	0.61	74	9.8	7.8	0.57	0.16	0.25	105
Duck	14	0.23	74	3.7	2.2	0.14	0.048	0.068	39

Source: ASABE Standard D384.2

1. Total manure is calculated from total solids and manure moisture content.

2. As excreted, manure moisture content ranges from 75-90%. At these moisture levels, manure has a density equal to that of water; a specific gravity of 1.0 was assumed in the calculation of manure volume.

3. f-a = finished animal

Table 2. Estimated typical manure characteristics as excreted by all other livestock and poultry

Animal type and production grouping	Total manure[1]		Moisture[2]	Total solids	Volatile solids	Nitrogen (N)	Phosphorus (P)	Potassium (K)
	lb/d-a	cu. ft. d-a	% wet basis	Pounds per day per animal (lb/d-a)				
Beef								
Confined cow [3, 4]	—	—	88	15	13	0.42	0.097	0.30
Confined growing calf	50	0.81	88	6.0	5.0	0.29	0.055	0.19
Dairy								
Lactating cow	150	2.4	87	20	17	0.99	0.17	0.23
Dry cow	83	1.3	87	11	9.2	0.50	0.066	0.33
Heifer (970 lb)	48	0.78	83	8.2	7.1	0.26	–	–
Horse (1,100 lb)[5]								
Sedentary	56	0.90	85	8.4	6.6	0.20	0.029	0.060
Intensive exercise	57	0.92	85	8.6	6.8	0.34	0.073	0.21
Poultry								
Layer	0.19	0.0031	75	0.049	0.036	0.0035	0.0011	0.0013
Swine								
Gestating sow (440 lb)	11	0.18	90	1.1	0.99	0.071	0.020	0.048
Lactating sow[6] (423 lb)	25	0.41	90	2.5	2.3	0.19	0.055	0.12
Boar (440 lb)	8.4	0.13	90	0.84	0.75	0.061	0.021	0.039

Source: ASABE Standard D384.2

1. Total manure is calculated from total solids and manure moisture content.

2. As excreted, manure moisture content ranges from 75-90%. At these moisture levels as excreted, manure has a density equal to that of water. A specific gravity of 1.0 was assumed in the calculation of manure volume.

3. Solids estimates do not include solids in urine.

4. Beef-cow values are representative of animals during nonlactating periods and the first six months of gestation.

5. These values apply to horses 18 months of age or older that are not pregnant or lactating. The representative number applies to 1,100-lb horses, and the range represents horses from 880 lb to 1,320 lb. “Sedentary” applies to horses not receiving any imposed exercise.

6. Nitrogen and phosphorus values include contribution of nursing pigs.

7. A dash (—) indicates no sample for the cell.

Why Store Manure?

Manure is stored so that it can be used effectively as a fertilizer to produce crops, decrease handling costs, and minimize the potential to pollute the environment. Storage allows effective use of manure nutrients when applied at a time when nutrients can be available to crops (before planting and on actively growing pastures) and soil conditions are right. When manure is applied at agronomic rates, you get the maximum benefits of manure as a fertilizer and reduce the risks of groundwater and surface water contamination from nutrients and pathogens that may be contained in the manure.

The properties of manure can change over time due to natural degradation processes or the loss of volatile compounds. Manure storage keeps manure in one location, making it convenient to sample for content analysis to determine its fertilizer value (e.g., nitrogen, phosphorus, and potassium). When sampling manure, be sure to obtain a representative sample. This information – combined with knowledge of the crop production needs (amount of manure applied per acre) and corresponding losses of nutrients because of application and storage – determines whether additional commercial fertilizer is needed to meet realistic crop production goals.

Adequate manure storage reduces the need for land application when weather and soil conditions are not favorable, i.e., during winter months when soil is saturated or frozen. This improves efficiency, saves wear and tear on equipment, conserves nutrients contained

in the manure, and minimizes manure nutrient leaching and runoff. Storage may allow additional farm acreage to be used for manure spreading because applications can be made when the risks of leaching or runoff are minimized.

Types of Manure Storages

Manure storage type depends on how the manure is handled. Manure can be handled as liquid, slurry, semisolid, or solid. The total solids (dry matter) and preferred method for manure application/utilization (figure 1) influence the choice of storage system.

Liquid Manure Storage

Used for manure with up to 10 percent solids content. Usually, water is added to make manure flow. Manure storage structures include belowground tanks or pits (either separate or under the animal housing), earthen storage ponds, and aboveground, fabricated concrete or steel tanks. Liquid manure is best handled with manure pumps, but gravity can also be used to transport liquid manure.

To produce liquid manure that can be handled with pumps, you may need to add dilution water or separate solids from the liquid. Keep in mind that adding water will increase the volume of material to be stored and separated solids will need to be handled separately. Manure with a solids content of less than 4 percent is best for pumping. Manure with solids content between 4 percent and 10 percent is sometimes called slurry. If you choose to use pumps to move liquid manure, check manure pump manufacturer recommendations for pump operation and for its appropriateness for the type of manure you want to pump. Liquid manure storages are suitable for operations where manure is flushed or scraped with the addition of some liquid, such as on dairy and swine farms.

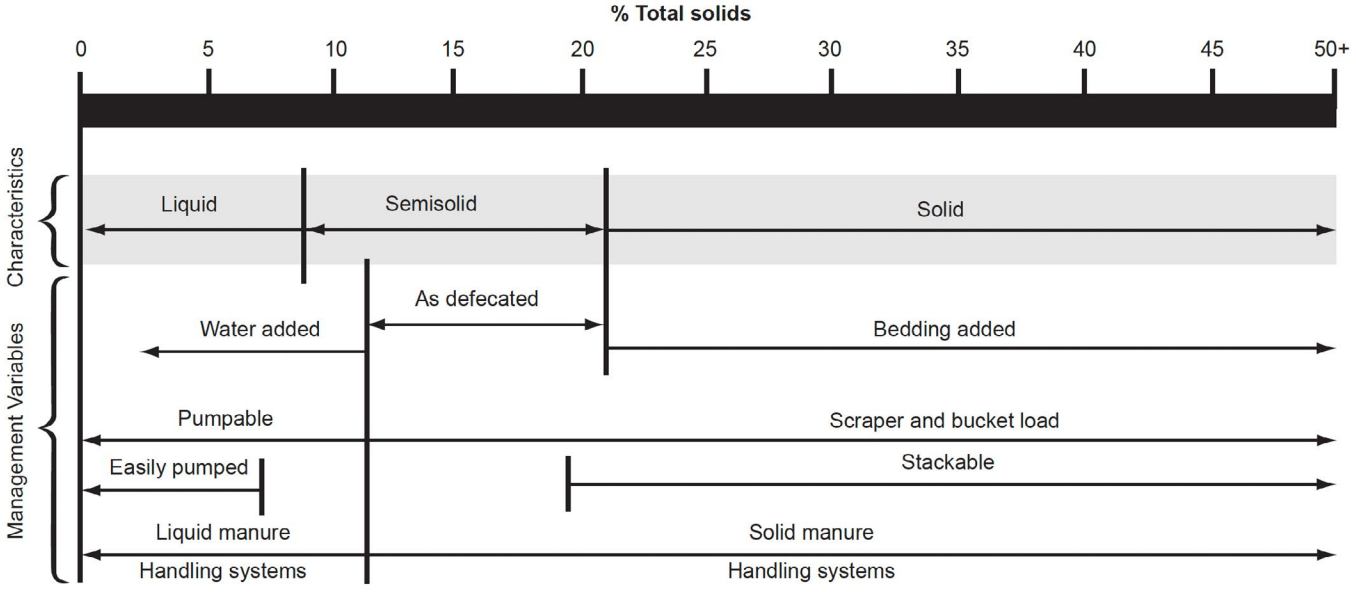
Semisolid Manure Storage

Used for manure with 10 percent to 20 percent solids content. Semisolid manure may "stack" if some bedding is added, although semisolid manure will not stack as well as solid manure. Semisolid manure storage facilities include aboveground structures – with or without roofs – aboveground silos or rectangular tanks, earthen or concrete banks with concrete floors, and roofed vertical-wall structures. Uncovered semisolid and solid manure storages will need containment for any accidental leaks or runoff due to excessive rainfall events. This storage type is common in dairy cattle, swine, horse, and poultry operations.

Solid Manure Storage

Used for manure with 20 percent to 25 percent or more solids content. Solid manure can be stacked and is best handled with a scraper and front-end loader. Solid manure is common where bedding is added to absorb liquid or drain off liquid and allow it to air dry. Solid manure is common in dairy cattle, beef cattle, horse, sheep, and goat operations. Solid manure can be stored in roofed stacking structures, concrete or earthen-baked structures with concrete floors, picket dams (retain manure solids on one side but the liquid flows through the dam into storage or treatment), and bedded packs.

Figure 1. Manure total solids characterization and handling requirements.



Typical Manure Storage for Different Animal Species

Dairy Cattle

Manure can be stored as liquid in a manure storage pit, tank, or earthen pond. Semisolid or solid manure can be stored in a stacked facility; solid manure can also be stored in a bedded pack. Milking-house wastewater and contaminated runoff must be stored as a liquid. Bedding plays an important role in determining the manure storage for dairy cattle. If sand is used as bedding, the manure storage will most likely be liquid.

Beef Cattle

Manure can be stored as solid in a bedded pack in a confinement area where bedding is added in sufficient quantities. Manure can also be stored as liquid or slurry, depending on its consistency. Solid manure can also be stored in dry stack structures.

Poultry

Litter from broiler and turkey operations is stored on the floor of the housing facility; when removed, it can be transported directly to the field for land application. If field conditions are not favorable, litter must be removed and stored outside the house in temporary or permanent structures as described in *Storing and Handling Poultry Litter*, Virginia Cooperative Extension (VCE) publication 442-054. Manure from layers can be stored in a roofed facility. If it is wet, consider using a structural tank or earthen storage pond.

Swine

Swine manure is usually stored as a liquid or slurry. Manure storage can be in outdoor tanks, earthen pits or part of anaerobic lagoons used for manure treatment.

Sheep, Goats, and Alpacas

Manure from these animals can be managed as solids. Where animals are grown on the pasture, proper stocking, pasture rotation, and grazing management will assist in nutrient dispersion. For animals in confinement, manure is periodically removed by scraping for immediate land application or storage in stacks.

Horses

Horse stalls receive liberal beddings and so most manure is handled as solids. If possible, manure should be used from stalls daily if possible and land applied. Manure can be stored as solids in stack structures and/or composted.

Planning a Manure Storage System

Plan a manure storage and management system carefully in order to ensure production efficiency, allow for future expansion, protect the environment, and meet regulatory guidelines. Some guidelines to use in planning and selecting a manure storage facility are discussed below.

Size/Capacity of Storage

The required capacity of a manure storage unit depends on the volume of the manure, volume of bedding and other waste streams, extra storage depth required for freeboard and precipitation, and length of time the manure will be stored. The Virginia Natural Resources and Conservation Service (NRCS) provides guidelines on how to properly size storage structures. The document is available at: https://efotg.sc.egov.usda.gov/api/CPSFile/528/313_VA_CPS_Waste_Storage_Facility_2017. A brief description of what to consider when sizing the storage unit is listed below.

Manure, Wastewater, Wasted Feed, Bedding and Other Recoverable Material

Manure volume depends on animal age, species, diet, and other factors. The size of the animal affects the amount of manure produced. In general, the larger the animal, the more manure it produces. Manure production characteristics of different animals are provided in tables 1 and 2. Other sources of waste include spilled feed, overflowed drinking water, cleansers, medicines, hair, etc., that may be included in the manure and must be taken into consideration when designing storage facilities. Reduce other sources of waste when possible because they increase production costs (e.g., additional feed to account for spill, loss of clean water) and may be hard on equipment.

Increase the storage size according to the quantity of other sources of waste to be stored. When possible, actual quantities of bedding and drinking water losses should be used in the design calculations. Include the volume of milking-center wastewater for dairy farms and water for cleaning buildings between cycles for hogs. This amount varies from farm to farm, and the actual volume used on the farm should be measured and used in the design of the storage tank.

Precipitation and Runoff

Extra storage depth must be provided to allow for precipitation and mandatory freeboard. This is usually based on normal precipitation less the evaporation on

the surface area of the storage facility, and the 25-year, 24-hour rainfall on the surface of the facility. The 25-year, 24-hour rainfall information can be obtained from Virginia NRCS offices or at the following website: www.va.nrcs.usda.gov/technical/hydrology.html. Include the volume of normal runoff and the 25-year, 24-hour runoff from the facility's drainage area during the storage period. Minimize the discharge of nonpolluted runoff into the storage structure.

Once the capacity of the required storage is known, the dimensions of the storage structure can be calculated.

Where to Locate a Manure Storage Facility

Consider all farmstead operations, locations of buildings and potable water wells, surface waters, future building expansions, prevailing winds, trees, and neighbors. Locate, size, and construct storage facilities for convenient filling and emptying and provide an all-weather access road.

Minimum separation distances from points of interest listed in table 3 should be observed. All efforts should be made to meet current Virginia recommendations and regulations.

Some other points to note include:

- Locate the manure storage structure as close to the source as possible and outside of flood plains. If site restrictions exist and require location within a flood plain, protect the storage structure from inundation or damage from a 100-year flood event or what is stipulated in the regulations, laws, and rules.

- Observing these separation distances when locating a new facility is a good way to help protect your drinking water. Locate manure storage facilities downslope from the well to protect your water supply. While observing the minimum distance for well separation may help to protect your own well, poorly designed or poorly maintained animal manure storage facilities could still contaminate the groundwater that supplies other local drinking-water wells. Protecting the groundwater resource as a whole can help protect your neighbors' wells, and the quality of drinking water supplies for future generations. If land constraints do not allow for this, it is very important that the manure and livestock lots be covered or contained, reducing or eliminating runoff from these areas.

Table 3. Natural Resources Conservation Service: Virginia guidelines for minimum distance requirements for waste storage facilities

Public or private facilities	Minimum distance from waste storage facility
Any public-use area (e.g., church, picnic area, playground, park, cemetery)	700 ft (215 m)
Drainage ditch	100 ft (30 m)
Milking parlor	100 ft (30 m)
Natural water course	200 ft (60 m)
Private potable well	100 ft (30 m)
Public potable well	300 ft (90 m)
Residence or place of habitation (other than owner or tenant)	700 ft (215 m)
Area specified by state or local ordinance	Greater of state or local distance or distance shown above

- Locate facilities to minimize the potential impacts from breach of embankments, accidental release, and liner failure.

- Provide enough separation distance to minimize the impact of odor from the storage facility.

Locate manure storage areas for practical loading and unloading. When using equipment such as a front-end loader, manure storage areas with a corner push-up wall can be useful. Earthen, wooden, or precast concrete-block walls can also help with containment and with diverting clean storm water from entering the manure storage area.

Site Guidelines

- Do not locate unlined storages over limestone, gravel, or fractured bedrock. If any of these conditions are present, check with your local Extension, NCRS, or SWCD to find out if there are any local and state environmental regulations, and consult a registered professional engineer.

- Do not locate unlined storages at/or below the water table. Virginia requires 2 feet or more separation distance between the storage bottom and high-water table, but check with local environmental regulatory agencies before building.

Figure 2. Types of manure storages (clockwise from top left): aboveground steel tank for liquid or semiliquid manure, aboveground concrete tank for liquid or semiliquid manure, earthen pond for liquid or semisolid manure, and stack shed for solid manure.

- Do not locate unlined storages in sandy or gravel-like soils, because these soils allow seepage to percolate through to the groundwater more easily. The NRCS can often help analyze the suitability of various sites for manure storage facility sites.

- Check for buried utilities and drainage tiles before building. These must be rerouted before construction or another site must be selected.

Storage Period

The storage period is the maximum length of time anticipated between emptying events. The minimum storage period is 120 days or what the storage needs to utilize the manure according to the nutrient management plan. Six months is the optimal storage period based on timing required for environmentally safe waste utilization considering climate, crops, soil, equipment, and local, state, and federal regulations.

Personal Preference

Select a manure storage system that matches your management strengths and abilities. For example, if you have an off-farm job, you may want to avoid systems with a lot of daily labor. For manure storage management and safety, see Poultry and Livestock Manure Storage: Management and Safety, VCE publication 442-308 (https://www.pubs.ext.vt.edu/442/442-308/442-308.html).

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Resources

American Society of Agricultural and Biological Engineers. 2005. *Manure Production and Characteristics*. ASABE D384.2.

MidWest Plan Service. 1993. *Livestock Waste Facilities Handbook*. 3rd ed. MWPS-18. Iowa State University. https://www-mwps.sws.iastate.edu/.

Natural Resources Conservation Service, Virginia. 2020. *Conservation Practice Standard. Nutrient Management Code 590*. https://efotg.sc.egov.usda.gov/api/CPSFile/39_0/590_VA_CPS_Nutrient_Management_2020.

Natural Resources Conservation Service, Virginia. 2017. *Conservation Practice Standard. Waste Storage Facility (Code 313)*. https://efotg.sc.egov.usda.gov/api/CPSFile/528/313_VA_CPS_Waste_Storage_Facility_2017.

Natural Resources Conservation Service, Virginia. 2017. *Operation & Maintenance Plan Waste Storage Facility (Code 313)*. https://efotg.sc.egov.usda.gov/api/CPSFile/530/313_VA_OM_Waste_Storage_Facility_2017.

Virginia Cooperative Extension. 2009. S*toring and Handling Poultry Litter*. VCE publication 442-054. https://www.pubs.ext.vt.edu/442/442-054/442-054.html.

Other Helpful VCE Publications

Virginia Cooperative Extension. 2024. *Poultry and Livestock Manure Storage: Management and Safety*. VCE publication 442-308. http://pubs.ext.vt.edu/442/442-308.

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