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Chapter 4 Agricultural Waste Characteristics

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Chapter 4 Agricultural Waste Characteristics

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651.0400 Introduction

(a) Purpose and scope

Wastes and residue described in this chapter are of an organic nature and agricultural origin. Some other wastes of nonagricultural origin that may be managed within the agricultural sector are also included. Information and data presented can be used for planning and designing waste management systems and system components and for selecting waste handling equipment.

(b) Variations and ranges of data values

In most cases a single value is presented for a specific waste characteristic. This value is presented as a reasonable value for facility design and equipment selection for situations where site specific data are not available. Waste characteristics are subject to wide variation; both greater and lesser values than those presented can be expected. Therefore, much attention is given in this chapter to describing the reasons for data variation and to giving planners and designers a basis for seeking and establishing more appropriate values where justified by the situation.

Onsite waste sampling, testing, and data collection are valuable assets in waste management system planning and design and should be used where possible. Such sampling can result in greater certainty and confidence in the system design and in economic benefit to the owner. However, caution must be exercised to assure that representative data and samples are collected. Characteristics of “as excreted” manure are greatly influenced by the effects of weather, season, species, diet, degree of confinement, and stage of the production/reproduction cycle. Characteristics of stored and treated wastes are strongly affected by such actions as sedimentation, flotation, and biological degradation in storage and treatment facilities.

651.0401 Definitions of waste characterization terms

Table 4–1 gives definitions and descriptions of waste characterization terms. It includes abbreviations, definitions, units of measurement, methods of measurement, and other considerations for the physical and chemical properties of manure, waste, and residue.

The first four physical properties—weight (Wt), volume (Vol), total solids (TS), and moisture content (MC)—are important to agricultural producers and facility planners and designers. They describe the amount and consistency of the material to be dealt with by equipment and in treatment and storage facilities. The first three of the chemical constituents—nitrogen (N), phosphorus (P), and potassium (K)—are also of great value to waste systems planners, producers, and designers. Land application of agricultural waste is the primary waste utilization procedure, and N, P, and K are the principal components considered in development of an agricultural waste management plan.

Total solids and the fractions of the total solids that are volatile solids (VS) and fixed solids (FS) are presented. Volatile solids and fixed solids are sometimes referred to, respectively, as total volatile solids (TVS) and total fixed solids (TFS). Characterization of these solids gives evidence of the origin of the waste, its age and previous treatment, its compatibility with certain biological treatment procedures, and its possible adaptation to mechanical handling alternatives.

Waste that has a very high water content may be characterized according to the amounts of solids that are dissolved and/or suspended. Dissolved solids (DS) or total dissolved solids (TDS) are in solution. Suspended solids (SS) or total suspended solids (TSS) float or they are kept buoyant by the velocity or turbulence of the wastewater.

Table 4–1 Definitions and descriptions of waste characterization terms (% w.b. is percent measured on a wet basis, and % d.b. is percent measured on a dry basis)

Term	Abbre-viation	Units of measure	Definition	Method of measurement	Remarks
Physical Properties					
Weight	Wt	lb	Quantity or mass.	Scale or balance.	
Volume	Vol	ft^3; gal	Space occupied in cubic units.	Place in or compare to container of known volume; calculate from dimensions of containment facility.	
Moisture content	MC	%	That part of a waste material removed by evaporation and oven drying at 217 °F (103 °C).	Evaporate free water on steam table and dry in oven at 217 °F for 24 hours or until constant weight.	Moisture content (%) plus total solids (%) equals 100%.
Total solids	TS	% % w.b.; % d.w.	Residue remaining after water is removed from waste material by evaporation; dry matter.	Evaporate free water on steam table and dry in oven at 217 °F for 24 hours or until constant weight.	Total of volatile and fixed solids; total of suspended & dissolved solids.
Volatile solids	VS; TVS	% % w.b.; % d.w.	That part of total solids driven off as volatile (combustible) gases when heated to 1112 °F (600 °C); organic matter.	Place total solids residue in furnace at 1112 °F for at least 1 hr.	Volatile solids determined from difference of total and fixed solids.
Fixed solids	FS; TFS	% % w.b.; % d.w.	That part of total solids remaining after volatile gases driven off at 1112 °F (600 °C); ash.	Determine weight (mass) of residue after volatile solids have been removed as combustible gases when heated at 1112 °F for at least 1 hr.	Fixed solids equal total solids minus volatile solids.
Dissolved solids	DS; TDS	% % w.b.; % d.w.	That part of total solids passing through the filter in a filtration procedure.	Pass a measured quantity of waste material through 0.45 micron filter using appropriate procedure; evaporate filtrate and dry residue to constant weight at 217 °F.	Total dissolved solids (TDS) may be further analyzed for volatile solids and fixed dissolved solids parts.
Suspended solids	SS TSS	% % w.b.; % d.w.	That part of total solids removed by a filtration procedure.	May be determined by difference between total solids and dissolved solids.	Total suspended solids may be further analyzed for volatile and fixed suspended solids parts.

Table 4–1 Definitions and descriptions of waste characterization terms — Continued

Term	Abbre-viation	Units of measure	Definition	Method of measurement	Remarks
Chemical Properties					
Ammoniacal nitrogen (total ammonia)		mg/L µg/L	Both NH_3 and NH_4 nitrogen compounds.	Common laboratory procedure uses digestion, oxidation, and reduction to convert all or selected nitrogen forms to ammonium that is released and measured as ammonia.	Volatile and mobile nutrients; may be a limiting nutrient in land spreading of wastes and in eutrophication.
Ammonia nitrogen	NH_3–N	mg/L µg/L	A gaseous form of ammoniacal nitrogen.		
Ammonium nitrogen	NH_4–N	mg/L µg/L	The positively ionized (cation) form of ammoniacal nitrogen.		Can become attached to the soil or used by plants or microbes.
Total kjeldahl nitrogen	TKN	mg/L µg/L	The sum of organic nitrogen and ammoniacal nitrogen.		
Nitrate nitrogen	NO_3–N	mg/L µg/L	The negatively ionized (anion) form of nitrogen that is highly mobile.		Nitrogen in this form can be lost by denitrification, percolation, runoff, and plant microbial utilization.
Total nitrogen	TN N	%; lb	The summation of nitrogen from all the various nitrogen compounds listed above.		Macro-nutrient for plants.
Phosphorus	P	%; lb	Acid-forming element that combines readily with oxygen to form the oxide P_2O_5. As a plant nutrient, it promotes rapid growth, hastens maturity, and stimulates flower, seed, and fruit production.	Laboratory procedure uses digestion and/or reduction to convert phosphorus to a colored complex; result measured by spectrophotometer.	Critical in water pollution control; may be a limiting nutrient in eutrophication and in spreading of wastes.

Table 4–1 Definitions and descriptions of waste characterization terms — Continued

Term	Abbre-viation	Units of measure	Definition	Method of measurement	Remarks
Chemical Properties					
Potassium	K	%; lb	As a plant nutrient, available potassium stimulates the growth of strong stems, imparts resistance to disease, increases the yield of tubers and seed, and is necessary to form starch, sugar, and oil and transfer them through plants.	Laboratory digestion procedure followed by flame photometric analysis to determine elemental concentration.	
5-day Biochemical Oxygen Demand	BOD_5	lb of O_2	That quantity of oxygen needed to satisfy biochemical oxidation of organic matter in waste sample in 5 days at 68 °F (20 °C).	Extensive laboratory procedure of incubating waste sample in oxygenated water for 5 days and measuring amount of dissolved oxygen consumed.	Standard test for measuring pollution potential of waste materials that could be discharged to surface water.
Chemical Oxygen Demand	COD	lb of O_2	Measure of oxygen consuming capacity of organic and some inorganic components of waste materials.	Relatively rapid laboratory procedure using chemical oxidants and heat to fully oxidize organic components of waste.	Estimate of total oxygen that could be consumed in oxidation of waste material.

Wastes are often given descriptive names that reflect their moisture content, such as liquid, slurry, semi-solid and solid. Wastes that have a moisture content of 95 percent or more exhibit qualities very much like water and are called liquid waste or liquid manure. Wastes that have moisture content of about 75 percent or less exhibit the properties of a solid and can be stacked and hold a definite angle of repose. They are called solid manure or solid waste. Wastes that have between about 75 and 95 percent moisture content—25 and 5 percent solids—are semi-liquid (slurry) or semi-solid. See chapter 9, section 651.0903. Because wastes are heterogeneous and inconsistent in their physical properties, the moisture content and range indicated above must be considered generalizations subject to variation and interpretation.

Table 4–1 also lists physical and chemical properties of livestock and other organic agricultural wastes. Data on biological properties, such as numbers of specific micro-organisms, are not presented in this chapter. Micro-organisms are of concern as possible pollutants of ground and surface water, but they are not commonly used as a design factor for no-discharge waste management systems that use wastes on agricultural land.

The terms manure, waste, and residue are sometimes used synonymously. In this chapter **manure** refers to combinations of feces and urine only, and **waste** includes manure plus other material, such as bedding, soil, wasted feed, and water that is wasted or used for sanitary and flushing purposes. Small amounts of wasted feed, water, dust, hair, and feathers are unavoidably added to manure and are undetectable in the production facility. These small additions must be considered to be a part of manure and a part of the "as excreted" characteristics presented. **Litter** is a specific form of poultry waste that results from "floor" production of birds after an initial layer of a bedding material, such as wood shavings, is placed on the floor at the beginning of and perhaps during the production cycle.

Because of the high moisture content of "as excreted" manure and treated waste, their specific weight is very similar to that of water—62.4 pounds per cubic foot. Some manure and waste that have considerable solids content can have a specific weight of as much as 105 percent that of water. Some dry wastes, such as litter, that have significant void space can have specific weight of much less than that of water. Assuming that wet and moist wastes weigh 60 to 65 pounds per cubic foot is a convenient and useful estimate for planning waste management systems.

Odors are associated with all livestock production facilities. Animal manure is a common source of significant odors, but other sources, such as poor quality or spoiled feed and dead animals, can also be at fault. Freshly voided manure is seldom a cause of objectionable odor, but manure that accumulates or is stored under anaerobic conditions does develop unpleasant odors. Such wastes can cause complaints at the production facility when the waste is removed from storage or when it is spread on the fields. Manure-covered animals and ventilation air exhausted from production facilities can also be significant sources of odor. The best insurance against undesirable odor emissions is waste management practices that quickly and thoroughly remove wastes from production facilities and place them in treatment or storage facilities or apply them directly to the soil.

651.0402 Units of measure

Waste production from livestock is expressed in pounds per day per 1,000 pounds of livestock live weight (lb/d/1000#). Volume of waste materials is expressed in cubic feet per day per 1,000 pounds of live weight (ft^3/d/1000#). Food processing waste is recorded in cubic feet per day (ft^3/d), or the source is included as in cubic feet per 1,000 pounds of apples processed. In this chapter English units are used exclusively for weight, volume, and concentration data for manure, waste, and residue.

The concentration of various components in waste is commonly expressed as milligrams per liter (mg/L) or parts per million (ppm). One mg/L is 1 milligram (weight) in 1 million parts (volume); for example, 1 liter. One ppm is 1 part by weight in 1 million parts by weight. Therefore, mg/L equals ppm if a solution has a specific gravity equal to that of water.

Generally, substances in solution up to concentrations of about 7,000 mg/L do not materially change the specific gravity of the liquid, and mg/L and ppm are numerically interchangeable. Concentrations are sometimes expressed as mg/kg or mg/1000g, which are the same as ppm.

Occasionally, the concentration is expressed in percent. A 1 percent concentration equals 10,000 ppm. Very low concentrations are sometimes expressed as micrograms per liter (µg/L). A microgram is 1 millionth of a gram.

Various solid fractions of a manure, waste, or residue, when expressed in units of pounds per day or as a concentration, generally are measured on a wet weight basis (% w.b.), a percentage of the "as is" or wet weight of the material. In some cases, however, data are recorded on a dry weight basis (% d.w.), a percentage of the dry weight of the material. The difference in these two values for a specific material is most likely very large. Nutrient and other chemical fractions of a waste material, expressed as a concentration, may be on a wet weight or dry weight basis, or expressed as pounds per 1,000 gallons of waste.

Amounts of the major nutrients, nitrogen (N), phosphorus (P), and potassium (K), are always presented in terms of the nutrient itself. Only the nitrogen quantity in the ammonium compound (NH_4) is considered when expressed as ammonium nitrogen (NH_4-N).

Commercial fertilizer formulations for nitrogen, phosphorus, and potassium and recommendations are expressed in terms of N, P_2O_5, and K_2O. When comparing the nutrient content of a manure, waste, or residue with commercial fertilizer, the conversion factors listed in table 4–2 should be used and comparisons on the basis of similar elements, ions, and/or compounds, should be made.

Table 4–2 Factors for determining nutrient equivalency

Multiply	By	To get
NH_3	0.824	N
NH_4	0.778	N
NO_3	0.226	N
N	1.216	NH_3
N	1.285	NH_4
N	4.425	NO_3
PO_4	0.326	P
P_2O_5	0.437	P
P	3.067	PO_4
P	2.288	P_2O_5
K_2O	0.830	K
K	1.205	K_2O
ppm	0.0083	lb/1000 gal

651.0403 Animal waste characteristics

Whenever locally derived values for animal waste characteristics are available, this information should be given preference over the more general data used in this chapter.

Carbon:nitrogen ratios were established using the ash content in percent (dry weight basis) to determine the carbon. The formula used, which estimates carbon in percent (dry weight basis), was:

$$C = \frac{100 - \%\text{ ash}}{1.8}$$

Total dissolved salts values were derived from a paper by R.M. Arrington and C.E. Pachek.

(a) "As excreted" manure

Daily "as excreted" manure production data are presented where possible in pounds per day per 1,000 pounds livestock live weight (lb/d/1000#) for typical commercial animals and birds. Units of cubic feet per day per 1,000 pounds live weight (ft^3/d/1000#) allow waste production to be calculated on a volumetric basis. Moisture content and total solids are given as a percentage of the total wet weight (% w.b.) of the manure. Total solids are also given in units of lb/d/1000#. Other solids data and the nutrient content of the manure are presented in units of lb/d/1000# on a wet weight basis.

"As excreted" manure characteristics are the most reliable data available. Manure and waste properties resulting from other situations, such as flushed manure, feedlot manure, and poultry litter, are the result of certain "foreign" materials being added and/or some manure components being lost from the "as excreted" manure. Much of the variation in livestock waste characterization data in this chapter and in other references results largely from the uncertain and unpredictable additions to and losses from the "as excreted" manure.

Livestock manure and waste produced in confinement and semi-confinement facilities are of primary concern and are given the greatest consideration in this chapter. Manure from unconfined animals and poultry, such as those on pasture or range, are of lesser significance because handling and distribution problems are not commonly encountered.

(b) Foreign material in manure

Foreign material commonly added to manure in the production facility are 1) bedding (litter), 2) wasted and spilled feed and water, 3) flush water, 4) rainfall, and 5) soil. These are often added in sufficient quantities to change the basic physical and chemical characteristics of the manure. The resulting combination of manure and foreign material is called waste. Dust, hair, and feathers are also added to manure and waste in limited amounts. Hair and feathers, especially, can cause clogging problems in manure handling equipment and facilities though the quantities may be small. Other adulterants are various wood, glass, and plastic items, and dead animals and birds.

(1) Bedding

Livestock producers use a wide range of bedding materials as influenced by availability, cost, and performance properties. Both organic and inorganic materials have been used successfully. Unit weights of materials commonly used for bedding dairy cattle are given in table 4–3.

Quantities of bedding materials used for dairy cattle are shown in table 4–4. The total weight of dairy manure and bedding is the sum of the weights of both parts. The total volume of dairy manure and bedding is the sum of the manure volume plus a half of the bedding volume. Only half of the bedding volume is used to compensate for the void space in bedding materials.

Broiler producers replace the bedding material after three to six batches or once or twice a year. The typical 20,000-bird house requires about 10 tons of wood shavings for a bedding depth of 3 to 4 inches.

(2) Wasted feed and water

Wasted feed has a great influence on the organic content of manure. Feed consumed by animals is 50 to 90 percent digested, but spilled feed is undigested. A pound of spilled feed results in as much waste as 2 to 10 pounds of feed consumed. Small quantities, about 3 percent, of wasted feed are common and very difficult to see. Wastage of 5 percent is common and can be observed. Obvious feed wastage is indicative of 10 percent or more waste. Anticipated feed waste of more than 5 percent should be compensated for as noted on the "as excreted" manure data summaries (tables 4–5, 4–8, 4–11, 4–14, 4–17, 4–18, 4–19, 4–20).

Wasted water must be expected and controlled. Excess moisture content and increased waste volume can hamper equipment operation and limit the capacity of manure handling and storage facilities. Faulty waterers and leaky distribution lines cause severe

Table 4–3 Unit weights of common bedding materials

Material	Loose	Chopped
	------- lb/ft^3 -------	
Legume hay	4.25	6.5
Nonlegume hay	4.00	6.0
Straw	2.50	7.0
Wood shavings	9.00	
Sawdust	12.00	
Soil	75.00	
Sand	105.00	
Ground limestone	95.00	

Table 4–4 Daily bedding requirements for dairy cattle

Material	---------- Barn type ----------		
	Stanchion stall	Free-stall	Loose housing
	------- lb/d/1000# -------		
Loose hay or straw	5.4		9.3
Chopped hay or straw	5.7	2.7	11.0
Shavings or sawdust		3.1	
Sand, soil, or limestone		1.5	

limitations and problems in the manure management system. Excess water from foggers and misters used for cooling stock in hot weather may be of concern in some instances.

(3) Soil

Soil is another natural adulterant of livestock manure. Its presence is most common on dairies on which the cows have access to paddocks and pastures. Dry soil adheres to the cows' bodies in limited amounts. Wet soil or mud adheres even more, and either falls off or is washed off at the dairy barn. Soil and other inorganic materials used for freestall base and bedding are also added to the manure. Soil or other inorganic materials commonly added to manure can result in a waste that has double the fixed solids content of "as excreted" dairy manure.

(c) Dairy

Manure characteristics for lactating and dry cows and for heifers are listed in table 4–5. These data are appropriate for herds of moderate to high milk production. Quantities of dairy manure vary widely from small cows to large cows and between cows at low production and high production levels. Figure 4–1 more accurately reflects these quantities of "as excreted" manure total solids and volatile solids where more precise data are desired. Dairy feeding systems and equipment often allow considerable feed waste, which in most cases is added to the manure. Feed waste of 10 percent can result in an additional 40 percent of total solids in a dairy waste. Dairy cow stalls are often covered with bedding materials that improve animal comfort and cleanliness. Virtually all of the organic and inorganic bedding materials used for this purpose will eventually be pushed, kicked, and carried from the stalls and added to the manure. The characteristics of these bedding materials will be imparted to the manure. Quantities of bedding materials added to cow stalls and resting areas are shown in table 4–4. See 651.0403(b), "Foreign material in manure," for additional information.

Milking centers—the milk house, milking parlor, and holding area—can produce about 50 percent of the waste volume, but only about 15 percent of the total solids in a dairy enterprise (table 4–6). Because this very dilute wastewater has different characteristics than the waste from the cow yard, it is sometimes managed by a different procedure. Values used to compute characteristics from milkhouses came from research by Cornell University completed in 1979 in New York.

About 5 to 10 gallons of fresh water per day for each cow milked are used in a milking center where flushing of wastes is not practiced. However, where manure flush cleaning and automatic cow washing are used, water use can be 150 gal/d/cow or more. Dairies employing flush cleaning systems use water in approximately the following percentages for various cleaning operations.

Parlor—cleanup and sanitation	10%
Cow washing	30%
Manure flushing	50%
Miscellaneous	10%

Lagoons that receive a significant loading of manure, such as from the holding area or the cow feed yard, generally operate in an anaerobic mode (table 4–7). Supernatant (upper liquid layer of the lagoon) concentration in an anaerobic lagoon is much greater than that in an aerobic lagoon. Anaerobic dairy lagoon

Table 4–5 Dairy waste characterization — as excreted*

Component	Units	Cow		Heifer
		Lactating	Dry	
Weight	lb/d/1000#	80.00	82.00	85.00
Volume	ft^3/d/1000#	1.30	1.30	1.30
Moisture	%	87.50	88.40	89.30
TS	% w.b.	12.50	11.60	10.70
	lb/d/1000#	10.00	9.50	9.14
VS	"	8.50	8.10	7.77
FS	"	1.50	1.40	1.37
COD	"	8.90	8.50	8.30
BOD_5	"	1.60	1.20	1.30
N	"	0.45	0.36	0.31
P	"	0.07	0.05	0.04
K	"	0.26	0.23	0.24
TDS		0.85		
C:N ratio		10	13	14

* Increase solids and nutrients by 4% for each 1% feed waste more than 5%.

sludge accumulates at a rate of about 0.073 cubic foot per pound of total solids added to the lagoon. This is equivalent to about 266 cubic feet per year for each 1,000 pound lactating cow equivalent (100% of waste placed in lagoon).

If a dairy waste lagoon receives wastewater only from the milk house or the milking parlor, the lagoon generally exhibits a very dilute supernatant and operates in an aerobic mode (table 4–7). The rate of sludge accumulation in such lagoons is slow.

Figure 4–1 allows a more specific estimation of dairy manure solids production based on lactating cow size and the level of milk production. The following examples show how this graph can be used.

Example 4–1: Estimate the daily production of total volatile and fixed solids in the manure of a 1,000 pound cow that is producing milk at the rate of 11,000 pounds per year.

Entering figure 4–1 on the horizontal scale at the annual milk production level of 11,000 pounds and projecting vertically to the TS and VS curves for the 1,000 pound cow and then horizontally to the vertical scale, the values of 8.9 lb/d and 7.6 lb/d are found for TS and VS, respectively. Fixed solids, which are determined by taking the difference between TS and VS, equal 1.3 lb/d (8.9 – 7.6).

Example 4–2: Estimate the daily production of total volatile and fixed solids in the manure of a herd of 125 cows of 1,400 pound average weight producing 19,200 pounds of milk per cow per year.

Entering figure 4–1 on the horizontal scale at the annual milk production level of 19,200 pounds and projecting vertically to the TS and VS curves for the 1,400 pound cow and then horizontally to the vertical scale, the values of 14.2 lb/d and 12.1 lb/d are found for TS and VS, respectively. Multiplying each of these values by 125, the number of cows in the herd, and determining FS from the difference of TS and VS, the daily manure solids produced by the herd are:

$$TS = (125 \times 14.2) = 1,775 \text{ lb / d}$$
$$VS = (125 \times 12.1) = 1,513 \text{ lb / d}$$
$$FS = (1,775 - 1,513) = 262 \text{ lb / d}$$

Table 4–6 Dairy waste characterization — milking center

Component	Units	Milking center* MH	MH+MP	MH+MP+HA **	MH+MP+HA ***
Volume	ft^3/d/1000#	0.22	0.60	1.40	1.60
Moisture	%	99.72	99.40	99.70	98.50
TS	% w.b.	0.28	0.60	0.30	1.50
VS	lb/1000 gal	12.90	35.00	18.30	99.96
FS	"	10.60	15.00	6.70	24.99
COD	"	25.30	41.70		
BOD	"		8.37		
N	"	0.72	1.67	1.00	7.50
P	"	0.58	0.83	0.23	0.83
K	"	1.50	2.50	0.57	3.33
C:N ratio		10	12	10	7

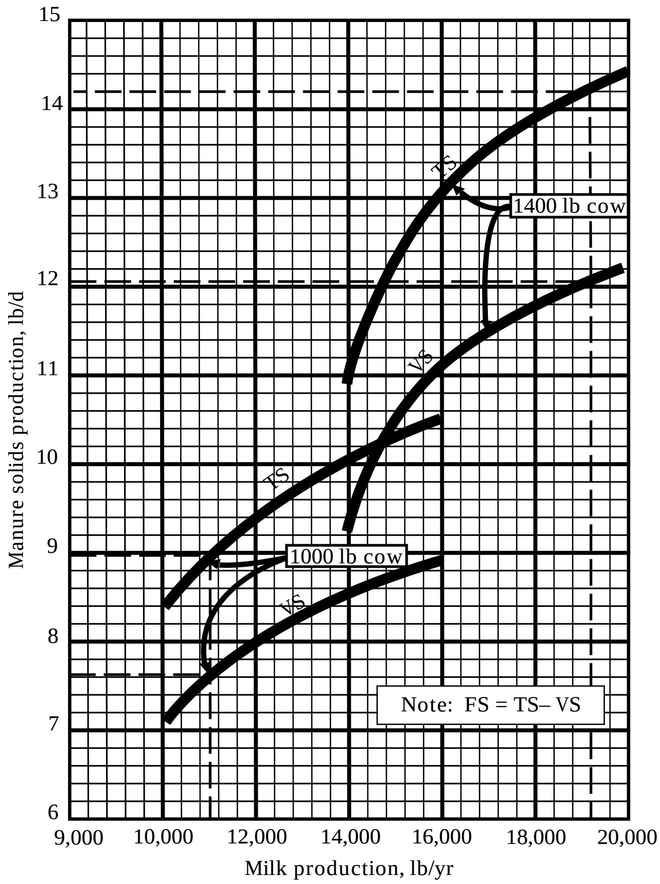
* MH – Milk house; MP – Milking parlor; HA – Holding area.
** Holding area scraped and flushed—manure excluded.
*** Holding area scraped and flushed—manure included.

Table 4–7 Dairy waste characterization — lagoon

Component	Units	Lagoon – Anaerobic Supernatant	Anaerobic Sludge	Aerobic* Supernatant
Moisture	%	99.75	90.00	99.95
TS	% w.b.	0.25	10.00	0.05
VS	lb/1000 gal	9.16	383.18	1.67
FS	"	11.66	449.82	2.50
COD	"	12.50	433.16	1.25
BOD_5	"	2.92`		0.29
N	"	1.67	20.83	0.17
NH_4-N	"	1.00	4.17	0.10
P	"	0.48	9.16	0.08
K	"	4.17	12.50	
C:N ratio		3	10	

* Milk house and milking parlor wastes only.

Figure 4–1 Dairy manure solids production



(d) Beef

Table 4–8 lists characteristics of "as excreted" beef manure. Beef waste of primary concern are those from the feedlots (table 4–9). The characteristics of these solid wastes vary widely because of such factors as climate, diet, feedlot surface, animal density, and cleaning frequency. The soil in unsurfaced beef feedlots is readily incorporated with the manure because of the animal movement and cleaning operations. Wasted feed is an important factor in the characterization of beef wastes.

Beef feedlot runoff water also exhibits wide variations in character (tables 4–10 & 4–10a). The influencing factors that are responsible for feedlot waste variations are similar to those listed for solid wastes. Surfaced feedlots produce more runoff than unsurfaced lots.

Table 4–8 Beef waste characterization — as excreted*

Component	Units	Feeder, yearling - 750 to 1,100 lb - High forage diet	High energy diet	450 to 750 lb	Cow
Weight	lb/d/1000#	59.10	51.20	58.20	63.00
Volume	ft^3/d/1000#	0.95	0.82	0.93	1.00
Moisture	%	88.40	88.40	87.00	88.40
TS	% w.b.	11.60	11.60	13.00	11.60
	lb/d/1000#	6.78	5.91	7.54	7.30
VS	"	6.04	5.44	6.41	6.20
FS	"	0.74	0.47	1.13	1.10
COD	"	6.11	5.61	6.00	6.00
BOD_5	"	1.36	1.36	1.30	1.20
N	"	0.31	0.30	0.30	0.33
P	"	0.11	0.094	0.10	0.12
K	"	0.24	0.21	0.20	0.26
C:N ratio	"	11	10	12	10

* Average daily production for weight range noted. Increase solids and nutrients by 4% for each 1% feed waste more than 5%.

Table 4–9 Beef waste characterization — feedlot manure

Component	Units	Unsurfaced lot*	- - Surfaced lot** - - High forage diet	High energy diet
Weight	lb/d/1000#	17.50	11.70	5.30
Moisture	%	45.00	53.30	52.10
TS	% w.b.	55.00	46.70	47.90
	lb/d/1000#	9.60	5.50	2.50
VS	"	4.80	3.85	1.75
FS	"	4.80	1.65	0.75
N	"	0.21		
P	"	0.14		
K	"	0.03		
C:N ratio		13		

* Dry climate (annual rainfall less than 15 inches); annual manure removal.
** Dry climate; semiannual manure removal.

Table 4–10 Beef waste characterization — feedlot runoff pond

Component	Units	- - - Runoff pond - - - Super-natant	Sludge
Moisture	%	99.70	82.80
TS	% w.b.	0.30	17.20
VS	lb/1000 gal	7.50	644.83
FS	"	17.50	788.12
COD	"	11.67	644.83
N	"	1.67	51.66
NH_4-N	"	1.50	
P	"		17.50
K	"	7.50	14.17

Table 4–10a Nitrogen content of cattle feedlot runoff (Alexander and Margheim 1974)[1]

Annual rainfall	Below-average conditions[2]	Average conditions[3]	Above-average conditions[4]
	- - - - - - - - - - - - lb N/acre-inch	- - - - - - - - - - - -	
<25 inches	360	110	60
25 to 35 inches	60	30	15
>35 inches	15	10	5

1 Applies to waste storage ponds that trap rainfall runoff from uncovered, unpaved feedlots. Cattle feeding areas make up 90 percent or more of the drainage area. Similar estimates were not made for phosphorus and potassium. Phosphorus content of the runoff will vary inversely with the amount of solids retained on the lot or in settling facilities.

2 No settling facilities are between the feedlot and pond, or the facilities are ineffective. Feedlot topography and other characteristics are conducive to high solids transport or cause a long contact time between runoff and feedlot surface. High cattle density—more than 250 head per acre.

3 Sediment traps, low gradient channels, or natural conditions that remove appreciable amounts of solids from runoff. Average runoff and solids transport characteristics. Average cattle density—125 to 250 head per acre.

4 Highly effective solids removal measures, such as vegetated filter strips or settling basins that drain liquid waste through a pipe to storage pond. Low cattle density—less than 120 head per acre.

(e) Swine

Swine waste and waste management systems have been widely studied, and much has been reported on swine manure properties. Table 4–11 lists characteristics of “as excreted” swine manure from feeding and breeding stock. More specific data on manure solids produced by growing swine ranging from 10 to 220 pounds are in figure 4–2. Breeding stock manure characteristics, also shown in table 4-11, are subject to less variation than those for growing animals. Wasted feed also significantly changes manure characteristics. A 10 percent feed waste increases manure total solids by 40 percent.

Ration components can make a significant difference in manure characteristics. Corn, the principal grain in swine rations, has a high digestibility (90%). Table 4–11 and figure 4–2 were developed for corn-based rations. If a grain of lower digestibility, such as barley (79%), is substituted for 50 percent of the corn in the ration, the total solids of the manure increase 41 percent and the volatile solids increase 43 percent above that of a ration based on corn. Wasted feed further increases the necessary size of storage units and lagoon facilities needed for manure from rations of lower digestibility.

A common procedure for collecting and storing swine waste under slatted floors is in deep or shallow tanks that may be allowed to overflow to lagoons or longer-term storage units. Daily accumulation of such waste cannot be accurately predicted. Table 4–12 presents concentration data on solids and nutrients in swine waste in tanks. Using these concentrations and the volume of waste on hand, plans for use of the waste can be made.

Swine waste storage structures and facilities must make allowances for wasted water. Small pigs, especially, play with automatic waterers and can waste up to 3 gallons of water per day per head. See section 651.0403(b)(2) for additional information. Table 4-13 gives data on the nature of rainfall runoff and settling basin sludge from surfaced swine feedlots exposed to precipitation.

Anaerobic lagoons have been used extensively for swine waste in the United States. Supernatant, the upper liquid layer, of properly operating swine lagoons is often brownish, chocolate, or purple. It's characteristics are listed in table 4–13. Light yellowish-green lagoon supernatant is generally less concentrated, and black generally is more concentrated than indicated in the table.

Sludge accumulates in a good anaerobic swine lagoon at a rate of 0.0485 cubic foot per pound of total solids placed in the lagoon. This is about 12 cubic feet per grower/finisher equivalent annually.

Table 4–11 Swine waste characterization — as excreted*

Component	Units	Grower 40 – 220 lb	Replacement gilt	Sow Gestation	Sow Lactation	Boar	Nursing/ nursery pig 0 – 40 lb
Weight	lb/d/1000#	63.40	32.80	27.20	60.00	20.50	106.00
Volume	ft^3/d/1000#	1.00	0.53	0.44	0.96	0.33	1.70
Moisture	%	90.00	90.00	90.80	90. 00	90.70	90.00
TS	% w.b.	10.00	10.00	9.20	10. 00	9.30	10.00
	lb/d/1000#	6.34	3.28	2.50	6.00	1.90	10.60
VS	"	5.40	2.92	2.13	5.40	1.70	8.80
FS	"	0.94	0.36	0.37	0.60	0.30	1.80
COD	"	6.06	3.12	2.37	5.73	1.37	9.80
BOD_5	"	2.08	1.08	0.83	2.00	0.65	3.40
N	"	0.42	0.24	0.19	0.47	0.15	0.60
P	"	0.16	0.08	0.06	0.15	0.05	0.25
K	"	0.22	0.13	0.12	0.30	0.10	0.35
TDS		1.29					
C:N ratio		7	7	6	6	6	8

* Average daily production for weight range noted. Increase solids and nutrients by 4% for each 1% feed waste more than 5%.

Figure 4–2 permits planners, designers, and others to estimate the manure solids production of growing swine in the weight range of 10 to 220 pounds.

Example 4–3: Estimate the total volatile and fixed solids produced daily in the manure of a 140-pound grower swine.

Entering figure 4–2 on the horizontal scale at an animal weight of 140 pounds, project vertically to the TS and VS curves and then horizontally to the vertical scale to read the values of 0.77 lb/d and 0.69 lb/d for the TS and VS, respectively. Fixed solids production is the difference between TS and VS values, or FS = 0.08 lb/d (0.77–0.69).

Example 4–4: Estimate the daily total volatile and fixed solids production in the manure of 450 grower/finisher swine with an average weight of 100 pounds. Enter figure 4–2 on the horizontal scale at weight of 100 pounds and project vertically to the TS and VS curves. Project horizontally to the vertical scale and read values of 0.63 lb/d and 0.57 lb/d for TS and VS, respectively. Multiplying by 450, the total number of animals, and determining fixed solids by the difference between TS and VS, the following amounts are determined:

$$TS = (125 \times 14.2) = 1,775 \text{ lb / d}$$

$$VS = (125 \times 12.1) = 1,513 \text{ lb / d}$$

$$FS = (1,775 - 1,513) = 262 \text{ lb / d}$$

Table 4–12 Swine waste characterization — storage tanks under slats

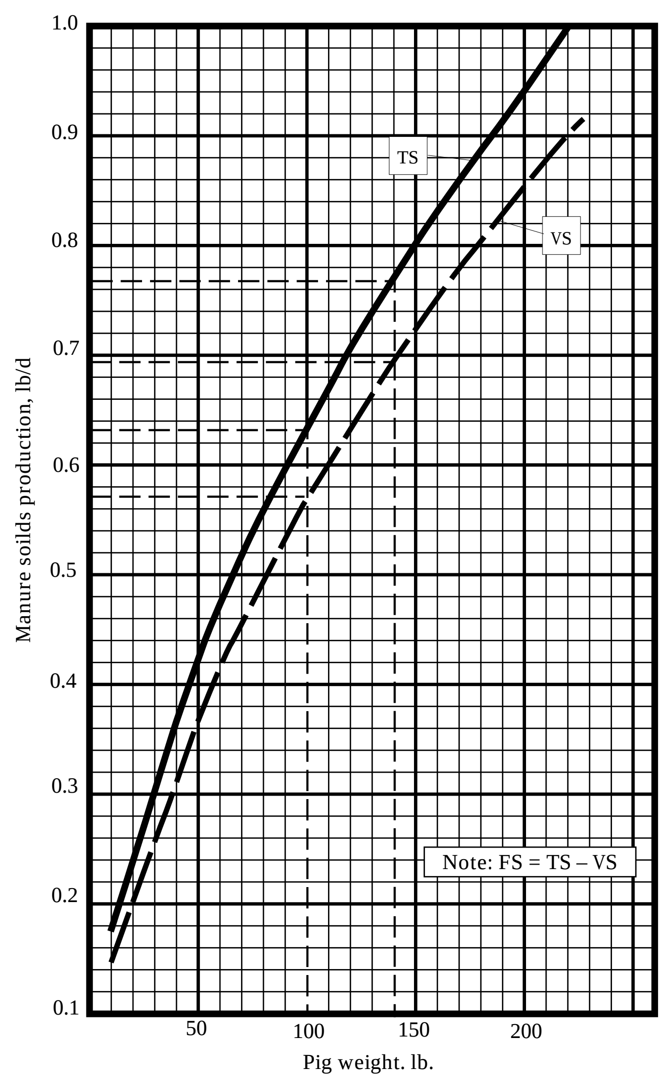
Component	Units	Farrow	Nursery	Grow/ finish	Breeding/ gestation
Moisture	%	96.50	96.00	91.00	97.00
TS	% w.b.	3.50	4.00	9.00	3.00
VS	lb/1000 gal	189.85	233.27	562.35	149.96
FS	"	101.64	99.97	187.45	99.97
N	"	29.16	40.00	52.48	25.00
NH_4-N	"	23.32	33.32		
P	"	15.00	13.32	22.50	10.00
K	"	23.32	13.32	18.33	17.50
C:N ratio		4	3	6	3

Table 4–13 Swine waste characterization — anaerobic lagoon; feedlot runoff

Component	Units	- Anaerobic lagoon - Supernatant	Sludge	- - Feedlot runoff* - - Runoff water	Settling basin sludge
Moisture	%	99.75	92.40	98.50	88.8
TS	% w.b.	0.25	7.60	1.50	11.2
VS	lb/1000 gal	10.00	379.89		90.7**
FS	"	10.83	253.27		21.3**
COD	"	10.00	538.18		
BOD_5	"	3.33			
N	"	2.91	25.00	2.00**	5.6**
NH_4-N	"	1.83	6.33	1.20**	4.5**
P	"	0.63	22.50	0.38**	2.2**
K	"	3.16	63.31	1.10**	10.0**
C:N ratio		2	8		

* Semi-humid climate (approx. 30" annual rainfall); annual sludge removal.
** lb/yr/1000#.

Figure 4–2 Manure solids production vs. pig weight for growing swine



(f) Poultry

Because of the high degree of industry integration, standardized rations, and complete confinement, layer and broiler manure characteristics vary less than those of other species. Turkey production is approaching the same status. Table 4–14 presents waste characteristics for “as excreted” poultry manure.

Table 4–14 Poultry waste characterization — as excreted*

Component	Units	Layer	Pullet	Broiler	Turkey	Duck
Weight	lb/d/1000#	60.50	45.60	80.00	43.60	
Volume	ft^3/d/1000#	0.93	0.73	1.26	0.69	
Moisture	%	75.00	75.00	75.00	75.00	
TS	% w.b.	25.00	25.00	25.00	25.00	
	lb/d/1000#	15.10	11.40	20.00	10.90	12.0
VS	"	10.80	9.70	15.00	9.70	7.0
FS	"	4.30	1.70	5.00	1.25	5.0
COD	"	13.70	12.20	19.00	12.30	9.5
BOD_5	"	3.70	3.30	5.10	3.30	2.5
N	"	0.83	0.62	1.10	0.74	0.7
P	"	0.31	0.24	0.34	0.28	0.3
K	"	0.34	0.26	0.46	0.28	0.5
TDS				2.89		
C:N ratio		7	9	8	7	6

* Increase solids and nutrients by 4% for each 1% feed waste more than 5%.

Table 4–15 lists data for poultry flocks that use a litter (floor) system. Bedding materials, whether wood, crop, or other residue, are largely organic matter that has little nutrient component. Litter moisture in a well managed house generally is in the range of 25 to 35 percent. Higher moisture levels in the litter result in greater weight and reduced levels of nitrogen.

Most broiler houses are now cleaned out one or two times a year. Growers generally have five or six flocks of broilers each year, and it is fairly common to take the "cake" out after each flock. The cake is generally 1 to 2 inches of material. About 2 or 3 inches of new litter is placed on the floor before the next flock. Much of the waste characterization data for broiler litter are based on five or six cycles per year.

When a grower manages for a more frequent, complete cleanout, the data in table 4–15 need adjustment. The birds still produce the same amount of N, P, and K per day. However, the density and moisture content of the litter is different with a more frequent cleanout and the nutrients are less concentrated. The amount of nutrients is less compared to the litter volume because less time is allowed for the nutrients to accumulate. A further complication is that nitrogen is lost to the atmosphere during storage while fresh manure is being continually deposited.

Table 4–15 Poultry waste characterization — litter

Component	Units	Layer high-rise*	Broiler	Turkey	Broiler breeder**	Duck**
Weight	lb/d/1000#	24.00	35.00	24.30		
Moisture	%	50.00	24.00	34.00	34.00	11.20
TS	% w.b.	50.00	76.00	66.00	66.00	88.80
	lb/d/1000#	12.00	26.50	16.10		
VS	"		21.40			58.60
FS	"		5.10			30.20
N	"	0.425	0.68	0.88	1.06	2.31
NH_4-N	"			0.01		
P	"	0.275	0.34	0.40	1.32	
K	"	0.30	0.40	0.45	1.19	
C:N ratio	"		9			14

* No bedding or litter material added to waste.
** All values % w.b.

Figure 4–3 shows the field determined relationship between the number of brood cycles between cleanouts and the nitrogen concentration in the litter after five cycles. The adjustment factor for five cycles is 1.0, thus no change. For example, a broiler producer generally has about 60 pounds of nitrogen per ton of broiler litter when a complete cleanout is done annually. The producer decides to do a complete cleanout after only one cycle. The nitrogen concentration would be about half that expected with an annual cleanout. Thus, only about 30 pounds of nitrogen would be in a ton of litter, so the producer would need to make twice as many trips to apply the same amount of nitrogen to the field. Figure 4–3 was developed using information from A.H. Stephenson, T.A. McCaskey, and B.G. Ruffin (Stephenson et al. 1989).

High-rise layer houses use no bedding and store manure for up to a year. Bird densities in high-rise houses have increased greatly in recent years, and the manure characteristics have been subject to great change. Use of current data for high-rise manure characterization is important.

As in other livestock operations, feed waste greatly increases the volume and organic content of the waste. A 10 percent wastage of feed, when added to the manure, increases total solids by 42 percent.

Poultry lagoon supernatant and sludge characteristics are in table 4–16. Anaerobic lagoon supernatant from good layer and pullet lagoons is brown, rosy, or burgundy. Yellowish-green supernatant is less concentrated. Blackish supernatant is more concentrated and generally has a higher value than those shown.

Layer lagoon sludge is much more dense than pullet lagoon sludge because of its high grit or limestone content. Layer lagoon sludge accumulates at the rate of about 0.0294 cubic foot per pound of waste total solids added to the lagoon, and pullet lagoon sludge accumulates at the rate of 0.0454 cubic foot per pound total solids. This is equivalent to about 0.6 cubic foot per layer and 0.3 cubic foot per pullet annually.

Figure 4–3 Curve to adjust broiler waste nitrogen concen-tration based on frequency of cleanout of litter

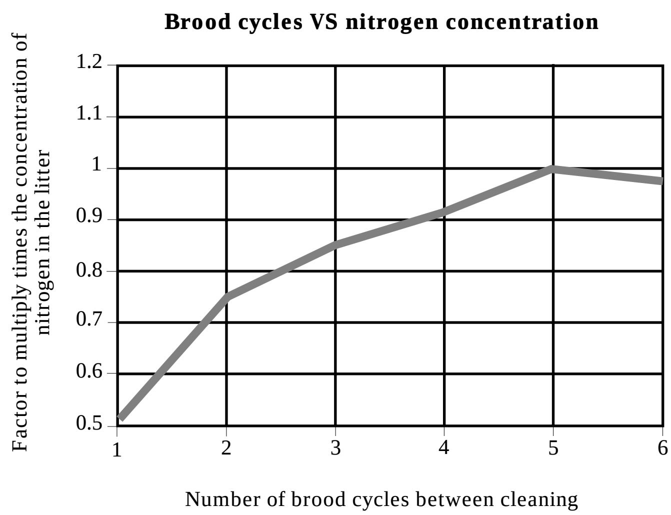


Table 4–16 Poultry waste characterization — anaerobic lagoon

Component	Units	------- Layer -------		------- Pullet -------	
		Super-natant	Sludge	Super-natant	Sludge
Moisture	%	99.50	86.90	99.70	92.60
TS	% w.b.	0.50	13.10	0.30	7.40
VS	lb/1000 gal	18.33	404.06	10.83	314.09
FS	"	23.32	687.32	14.17	302.42
N	"	6.25	32.50	3.00	24.17
NH_4-N	"	4.58	7.66	2.24	4.91
P	"	0.83	45.82	0.75	27.49
K	"	8.33	6.00	7.00	6.17
C:N ratio		2	7	2	7

(g) Veal

Data on manure characteristics from veal production are shown in table 4–17. Sanitation in veal production is an extremely important factor, and waste management facilities should be planned for handling as much as 3 gallons of wash water per day per calf.

Table 4–17 Veal waste characterization — as excreted

Component	Units	Veal feeder
Weight	lb/d/1000#	60.00
Volume	ft^3/d/1000#	0.96
Moisture	%	97.50
TS	% w.b.	2.50
	lb/d/1000#	1.50
VS	"	0.85
FS	"	0.65
COD	"	1.50
BOD_5	"	0.37
N	"	0.20
P	"	0.03
K	"	0.25
C:N ratio		2

(h) Sheep

"As excreted" manure characteristics for sheep are limited to those for the feeder lamb (table 4–18). In some cases bedding may be a significant component of sheep waste.

Table 4–18 Lamb waste characterization — as excreted*

Component	Units	Lamb
Weight	lb/d/1000#	40.00
Volume	ft^3/d/1000#	0.63
Moisture	%	75.00
TS	% w.b.	25.00
	lb/d/1000#	10.00
VS	"	8.30
FS	"	1.76
COD	"	11.00
BOD_5	"	1.00
N	"	0.45
P	"	0.07
K	"	0.30
C:N ratio		10

* Increase solids and nutrients by 4% for each 1% feed waste more than 5%.

(i) Horse

Table 4–19 lists characteristics of "as excreted" horse manure. Because large amounts of bedding are used in the stables of most horses, qualities and quantities of wastes from these stables generally are dominated by the kind and volume of bedding used.

Table 4–19 Horse waste characterization — as excreted*

Component	Units	Horse
Weight	lb/d/1000#	50.00
Volume	ft^3/d/1000#	0.80
Moisture	%	78.00
TS	% w.b.	22.00
	lb/d/1000#	11.00
VS	"	9.35
FS	"	1.65
N	"	0.28
P	"	0.05
K	"	0.19
C:N ratio		19

* Increase solids and nutrients by 4% for each 1% feed waste more than 5%.

(j) Rabbit

Some properties of rabbit manure are listed in table 4–20. The properties refer only to the feces; no urine has been included. Reliable information on daily production of rabbit manure, feces, or urine is not available.

Table 4–20 Rabbit waste characterization — as excreted*

Component	Units	Rabbit
VS	% d.b.	0.86
FS	"	0.14
COD	"	1.00
N	"	0.03
P	"	0.02
K	"	0.03
C:N ratio		16

* Increase solids and nutrients by 4% for each 1% feed waste more than 5%.

(k) Flush water

Hydraulic manure transport, or flush cleaning, is an effective method of manure collection and handling, but relatively large quantities of water are used. Small quantities of manure can be diluted 5 to 10 times in the cleaning process; therefore, waste handling problems are multiplied.

Because the resulting quantity of waste or wastewater is large, lagoons and irrigation equipment are usually parts of waste management systems using flush cleaning. While fresh water is required for cleaning in many instances, recycled lagoon liquid (supernatant) can be used and can greatly reduce the volume of fresh water needed for waste management. Where necessary, the approval of appropriate State and local authorities should be requested before lagoon supernatant recycling is implemented.

Because quantities of flush water vary widely between operations, it is recommended that estimated values be based on local calculations or measurement. Estimates of flush water requirements for various mechanisms and for various species may be made from the following equations and test results.

Swine — (siphon, gated tank, or tipping tank)

$$Q = 0.5\ L \times W \qquad [4\text{–}1]$$

where:
- Q = Flush water vol, gal/flush
- L = Gutter length, ft
- W = Gutter width, ft

Dairy

	Gated tank	Pump flush
Gal/d/ft² alley surface	2.5	15.0
Gal/d/cow	80.0	550.0

Dairies that have gated tank flush cleaning and automatic cow washing commonly use 100 to 150 gal/d/cow, but multiple flushing and alternative equipment may double this amount.

Poultry — (pump flush) 1.0 to 1.5 gal/bird/flush.

For more information on flush systems, refer to chapter 10.

651.0404 Other wastes

(a) Residential waste

Rural residential waste components are identified in tables 4–21 and 4–22. Table 4–21 lists the characteristics of human excrement. Household wastewater (table 4–22) can be categorized as graywater (no sanitary wastes included) and blackwater (sanitary wastewater). In most cases a composite of both of these components will be treated in a septic tank. The liquid effluent from the septic tank generally is treated in a soil absorption field.

Residential wastewater of municipal origin is usually categorized into raw (untreated) and treated types (table 4–23). Secondary (biological) treatment is common for wastewater that is to be applied to agricultural land. Municipal wastewater sludge may also be in the raw, untreated form or in the treated (digested) form. Municipal compost is usually based on dewatered, digested sludge and refuse, but can contain other waste materials as well (table 4–23).

Liquid and solid wastes of residential origin generally are not a source of toxic materials. Some industrial waste, however, may contain toxic components requiring careful handling and controlled distribution. Planning of land application systems for industrial waste must include thorough analyses of the waste materials.

Table 4–21 Human waste characterization — as excreted

Component	Units	Adult
Weight	lb/d/1000#	30.00
Volume	ft³/d/1000#	0.55
Moisture	%	89.10
TS	% w.b.	10.90
	lb/d/1000#	3.30
VS	"	1.93
FS	"	1.40
COD	"	3.00
BOD_5	"	1.30
N	"	0.20
P	"	0.02
K	"	0.07

Table 4–22 Residential waste characterization — household wastewater

Component	Units	Graywater	Composite*	Septage
Volume	ft^3/d/1000# of people	27.00	38.00	35.00
Moisture	%	99.92	99.65	99.75
TS	% w.b.	0.08	0.35	0.25
	lb/d/1000# of people	1.33	7.75	5.50
VS	% w.b.	0.024	0.20	0.14
FS	"	0.056	0.15	0.11
N	"	0.0012	0.007	0.0075
NH_4-N	"			0.0018
P	"	0.0004	0.003	0.0019
K	"		0.003	0.0025

* Graywater plus blackwater.

Table 4–23 Municipal waste characterization — residential

Component	Units	- - - - - Wastewater - - - -		- - - - - - Sludge - - - - - -		Compost*
		Raw	Secondary	Raw	Digested	
Volume	ft^3/d/1000# of people	90.00	85.00			
Moisture	%	99.95	99.95			40.00
TS	% w.b.	0.05**	0.05***	4.00	4.00	60.00
VS	"	0.035		3.00	2.10	
FS	"	0.015		1.00	0.90	
COD	"	0.045				
BOD_5	"	0.020	0.0025			
N	"	0.003	0.002	0.32	0.15	0.78
NH_4-N	"		0.001		0.08	
P	"	0.001	0.001	0.036	0.067	0.20
K	"	0.001	0.0012		0.010	0.17

* Origin is household refuse.
** Suspended solids 0.03%; dissolved solids 0.02%.
*** Suspended solids 0.0025%; dissolved solids 0.0475%.

(b) Food wastes and wastewater

Food processing can result in considerable quantities of solid waste and wastewater. Processing of some fruits and vegetables results in more than 50 percent waste. Many of these wastes, however, can be used in by-product recovery procedures, and not all of the waste must be sent to use or disposal facilities. Food processing wastewater may be a dilute material that has a low concentration of some of the components of the raw product. On the other hand, solid waste from food processing may contain a high percentage of the raw product and exhibit characteristics of that raw product.

Tables 4–24 and 4–25 present characteristics of wastewater and sludge from the processing of milk and milk products.

Characteristics of wastewater and sludge from the meat and poultry processing industries are listed in tables 4–26 and 4–27.

Table 4–26 presents data on raw wastewater discharges from red meat and poultry processing plants.

Table 4–27 describes various sludges. Dissolved air flotation sludge is a raw sludge resulting from a separation procedure that incorporates dissolved air in the wastewater. The data on wastewater sludge is for sludge from secondary treatment of wastewater from meat processing.

Table 4–28 presents raw wastewater qualities for several common vegetable crops on the basis of the amount of the fresh product processed.

Characteristics of solid fruit and vegetable wastes, such as might be collected at packing houses and processing plants, are listed in table 4–29.

Table 4–24 Dairy food processing waste characterization

Product/Operation	Wastewater: Weight lb/lb milk processed	Wastewater: BOD_5 lb/1000 lb milk received
Bulk milk handling	6.1	1.0
Milk processing	4.9	5.2
Butter	4.85	1.46
Cheese	2.06	1.8
Condensed milk	1.85	4.5
Milk powder	2.8	3.9
Milk, ice cream, & cottage cheese	2.52	6.37
Cottage cheese	6.0	34.0
Ice cream	2.8	5.76
Milk & cottage cheese	1.84	3.47
Mixed products	1.8	2.5

Table 4–25 Dairy food waste characterization — processing wastewater

Component	Units	Industry-wide	Whey: Sweet cheese	Whey: Acid cheese	Cheese wastewater sludge
Moisture	%	97.60	93.10	93.40	97.50
TS	% w.b.	2.40	6.90	6.60	2.50
VS	"	1.49	6.35	6.00	
FS	"	0.91	0.55	0.60	
COD	"		1.30		
BOD_5	"	2.00			
N	"	0.077	7.48		0.18
P	"	0.050			0.12
K	"	0.067			0.05

Table 4–26 Meat processing waste characterization — wastewater

Component	Units	Red meat Slaughter [1]	Red meat Packing [2]	Red meat Processing [3]	Poultry [4]	Broiler [5]
Volume	gal/1000# [6]	696.0	1,046.0	1,265.0	2,500.0	
Moisture	%					95.05
TS	% w.b.					4.95
	lb/1000# [6]	4.7	8.7	2.7	6.0	
VS	"					4.30
FS	"					0.65
BOD_5	"	5.8	12.1	5.7	8.5	
N	"					0.30
P	"					0.084
K	"					0.012

1 Slaughter—Killing and preparing the carcass for processing.
2 Packing—Killing, preparing the carcass for processing, and processing.
3 Processing—Butchering, grinding, packaging.
4 Quantities per 1,000 lb product.
5 All values % w.b.
6 Per 1,000 lb live weight killed.

Table 4–27 Meat processing waste characterization — wastewater sludge

Component	Units	Dissolved air flotation sludge Poultry	Dissolved air flotation sludge Swine	Dissolved air flotation sludge Cattle	Wastewater sludge
Moisture	%	94.20	92.50	94.50	96.00
TS	% w.b.	5.80	7.50	5.50	4.00
VS	% w.b.	4.80	5.90	4.40	3.40
FS	"	1.00	1.60	1.10	0.60
COD	"	7.80			
N	"	0.41	0.53	0.40	0.20
NH_4-N	"	0.17			
P	"	0.12			0.04

Table 4–28 Vegetable processing waste characterization — wastewater

Component	Units	Cut bean	French style bean	Pea	Potato	Tomato
Volume	ft^3/1000 lb				270*	
TS	lb/1000 lb†	15	43	39	53**	134
VS	"	9	29	20	50**	
FS	"	6	14	19	3**	
COD	"	14	35	37	71***	96
BOD_5	"	7	17	21	32	55

† Lb/1000 lb raw product. * Ft^3 per lb processed. ** Total suspended solids. *** Percent of TSS.

Table 4–29 Fruit and vegetable waste characterization — solid waste

Fruit/vegetable	Moisture content	Total solids	Volatile solids	Fixed solids	N	P	K
	- - - - - - - -	- - - - - - - -	- - - - Percent wet	weight basis - - - -	- - - - - - - -	- - - - - - - -	- - - - - - - -
Banana, fresh	84.0	16.0	13.9	2.1	0.53		
Broccoli, leaf	86.5	13.5			0.30		
Cabbage, leaf	90.4	9.6	8.6	1.0	0.14	0.034	
" core	89.7	10.3			0.38		
Carrot, top	84.0	16.0	13.6	2.4	0.42	0.03	
" root	87.4	12.6	11.3	1.3	0.25	0.04	
Cassava, root	67.6	32.4	31.1	1.3	1.68	0.039	
Corn, sweet, top	79.8	20.2	19.0	1.2	0.67		
Kale, top	88.4	11.6	9.7	1.9	0.22	0.06	
Lettuce, top	94.6	5.4	4.5	0.9	0.05	0.027	
Onion, top, mature	8.6	91.4	84.7	6.7	1.37	0.02	
Orange, flesh	87.2	12.8	12.2	0.6	0.26		
" pulp	84.0	16.0	15.0	1.0	0.24		
Parsnip, root	76.3	23.7			0.47		
Potato, top, mature	12.8	87.2	71.5	15.7	1.22		
" tuber					1.60	0.25	1.9
Pumpkin, flesh	91.3	8.7	7.9	0.8	0.12	0.037	
Rhubarb, leaf	88.6	11.4			0.20		
Rutabaga, top	90.0	10.0			0.35		
" root	89.5	10.5			0.20		
Spinach, stems	93.5	6.5			0.065		
Tomato, fresh	94.2	5.8	5.2	0.6	0.15	0.03	0.30
" solid waste	88.9	11.1	10.2	0.9	0.22	0.044	0.089
Turnip, top	92.2	7.8				0.20	
" root	91.1					0.34	

(c) Silage leachate

Leachate, a liquid by-product in which the potential for pollution is severe, results from the storage of forage materials for the production of silage. In general, the amount of leachate produced is directly influenced by the moisture content of the forage ensiled and the degree of compaction to which the forage is subjected. As a rule of thumb, it is suggested that storage facilities for silage leachate provide 1 cubic foot (7.5 gallons) capacity for each ton of forage placed in storage. If materials that have a moisture content of 80 percent or more are to be ensiled, even greater leachate quantities can be expected.

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