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The full document is available at: http://www.epa.gov/ost/guide/mpp/

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SECTION 6

WASTEWATER CHARACTERIZATION

In this section, the sources and general composition of the wastewaters generated by the meat and poultry products (MPP) industry are described. In addition, data collected by the EPA in a series of sampling episodes at selected meat and poultry processing facilities to quantify rates of wastewater generation and characterize composition before treatment are presented along with comparable data from other sources. The series of sampling episodes was part of the EPA data collection effort for final rule development. An overview of the data collection for the final rule development is presented in Section 3 of this document. Wastewaters generated during meat processing, poultry processing, and rendering are discussed in Sections 6.1 through 6.4.

6.1 MEAT PROCESSING WASTES

6.1.1 Volume of Wastewater Generated

In meat processing, water is used primarily for carcass washing after hide removal from cattle, calves, and sheep or hair removal from hogs and again after evisceration, for cleaning, and sanitizing of equipment and facilities, and for cooling of mechanical equipment such as compressors and pumps. A large quantity of water is used for scalding of hogs for hair removal before evisceration. Since most meat-processing facilities operate only five days per week with one killing and processing shift and followed by cleaning operations, the rate of water use and wastewater generation varies with both time of day and day of the week. In order to comply with Federal requirements for complete cleaning and sanitation of equipment after each killing and processing shift, a regular processing shift, usually of 8- or 10-hour duration, is followed by a 6- to 8-hour cleanup shift every day. During killing and processing, water use and wastewater generation are relatively constant and low compared to the cleanup period that follows. Water use and wastewater generation essentially cease after the cleanup period until processing begins the next day. In addition, there is little water use or wastewater generation on non-processing days, which usually are Saturdays and Sundays. Thus, meat processing wastewater flow rates can be highly variable, especially on an hourly basis.

A number of studies also have shown that the volume of water used and wastewater generated on a per unit of production basis, such as live weight killed (LWK) or finished product produced also can vary substantially among processing plants. Some of this variation is a reflection of different levels of effort among plants to minimize water use to reduce the cost of wastewater treatment. For example, Johns (1995) reported water use ranging from 312 to 601 gallons per 1,000 pounds (lb) live weight for processing of beef cattle. In an earlier EPA analysis of data from 24 simple slaughterhouses (operations producing fresh meat ranging from whole carcasses to smaller cuts of meat with two or fewer by-product recovery activities, such as rendering and hide processing), wastewater flows ranged from 160 to 1,755 gallons per 1,000 lb LWK with a mean value of 639 gallons per 1,000 lb LWK (USEPA, 1974). About one-half of these operations slaughtered beef cattle; with the remainder evenly divided between hogs and mixed kill. Two of the 24 simple slaughterhouses handled less 95,000 lb LWK per day and the remainder handled between 95,000 and 758,000 lb LWK per day. For 19 medium and large complex slaughterhouses (operations with three or more byproduct recovery activities), wastewater flows ranged from 435 to 1,500 gallons per 1,000 lb LWK with a mean value of 885 gallons per 1,000 lb LWK.

Table 6-1 presents the ranges of rates of wastewater flow on a 1,000 lb of LWK basis at three hog and three cattle processing facilities sampled by the EPA. Two of the hog processing facilities are first processing facilities with on-site rendering while activities at the third facility include further processing in addition to first processing and rendering. While all three of the cattle processing facilities are first processing facilities with on-site rendering, two also process hides on-site. As the values listed in Table 6-1 indicate, there is a considerable degree of variation among both hog and cattle processing facilities. Table 6-2 presents median rates of wastewater flow per unit of production derived from MPP detailed survey responses.

Table 6-1. Rates of Wastewater Generated at Three Hog and Three Cattle Processing Facilities (gallons/l,000 lbs LWK)[a]

Meat Type	First Processing	Further Processing	Rendering	Total
Hogs	123-309	118	50-133	291-442
Cattle (first processing and rendering)	390	NA[b]	142	532
Cattle (first processing, rendering and hide processing)	241-302	NA	63-84	304-386

[a] Data generated during the EPA sampling of MPP facilities
[b] NA = not applicable

Table 6-2. Wastewater Volumes Produced by Meat Facilities per Unit of Production [a]

	Process Wastewater Generated (gallons per 1,000 lbs of production unit)	
	First Processing[b]	Further Processing[c]
Non-small facilities	352	135

[a] Median values derived from the 58 MPP detailed survey responses (as describe in Section 3.2.6).
[b] Production unit for first processing operations is 1,000 lb of live weight killed (LWK). These numbers include facilities that may also generate wastewater from cutting operations.
[c] Production unit for further processing operations is 1,000 lb of finished product.

6.1.2 Description of Waste Constituents and Concentrations

The principal sources of wastes in meat processing are from live animal holding, killing, hide or hair removal, eviscerating, carcass washing, trimming, and cleanup operations. When present, further processing, rendering, and hide processing operations[1] also are significant sources of wastes. Meat processing wastes include blood not collected, viscera, soft tissue removed during trimming and cutting, bone, urine and feces, soil from hides and hooves, and various cleaning and sanitizing compounds. Further processing, rendering, and hide processing produce additional sources of fat and other soft tissues, as well as substances including brines, cooking oils, and tanning solutions. Wastewater characteristics of rendering operations are discussed in Section 6.3.

[1]Note that although not part of meat processing operations, hide processing wastewaters are often commingled with meat processing wastewaters prior to treatment. The existing regulations at 40 CFR Part 432, as well as the new regulations, address wastewaters from hide processing operations when discharged with meat processing wastewaters.

The principal constituents of meat processing wastewaters are a variety of readily biodegradable organic compounds, primarily fats and proteins, present in both particulate and dissolved forms. Screening of meat processing wastewaters is usually performed in most facilities to reduce concentrations of particulate matter before effecting pre-treatment.

Meat processing wastewaters remain high strength wastes, even after screening, in comparison to domestic wastewaters, based on concentrations of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), nitrogen, and phosphorus.

Blood not collected, solubilized fat, urine, and feces are the primary sources of BOD in meat processing wastewaters. For example, blood from beef cattle has a reported BOD of 156,500 mg/L with an average of 32.5 pounds of blood produced per 1,000 pounds LWK (Beefland International, Inc., 1971). Thus, the efficacy of blood collection is a significant factor in determining the amount of BOD in meat processing wastewater.

Another significant factor in determining the BOD of meat processing wastewaters is the manner in which manure (urine and feces) is handled at the facility. Generally, manure is separated from the main waste stream and treated as a solid waste. Beef cattle manure has a BOD of approximately 27,000 mg/kg on an as excreted basis, and the BOD of swine manure is approximately 37,000 mg/kg of manure (American Society of Agricultural Engineers, 1999).

The efficiency of fat separation and removal from the waste stream is an important factor in determining the BOD concentration in meat processing wastewaters. Fat removed from wastewater can be handled as a solid waste or by-product. The high BOD of animal fats is directly attributable to their rapid biodegradability and high-energy yield for microbial cell maintenance and growth, especially under aerobic conditions. The significance of fat as a component of BOD in meat processing wastewaters generally is determined indirectly as the concentration of oil and grease (Standard Methods APHA 1995). In the determination of oil and grease, the concentration of a specific substance is not determined. Instead, groups of compounds with similar physical characteristics are determined quantitatively based on their common solubility in an organic extracting solvent. Over time, petroleum ether has been replaced by trichlorotrifluoroethane (Freon) and most recently by n-hexane as the preferred extracting solvent. Thus, oil and grease concentrations in meat processing wastewaters may be reported as Freon or n-hexane extractable material (HEM).

Blood and manure are also are significant sources of nitrogen in meat processing wastewaters. The principal form of nitrogen in these wastewaters before treatment is organic nitrogen with some ammonia nitrogen. During collection of wastewater samples, some ammonia nitrogen is produced by the microbially mediated mineralization of organic nitrogen. Nitrite and nitrate nitrogen generally are present only in trace concentrations (less than 1 mg/L) in meat processing wastewaters; however, these nitrate and nitrite concentrations are increased when nitrites are used in processes such as the curing of bacon and ham. The phosphorus in meat processing wastewaters is primarily from blood, manure, and cleaning and sanitizing compounds, which can contain trisodium phosphate (sodium phosphate, tribasic).

Due to the presence of manure in meat processing wastewaters, densities of total coliform, fecal coliform, and fecal streptococcus groups of bacteria generally are on the order of several million colony forming units (cfu) per 100 mL. Although members of these groups of microorganisms generally are not pathogenic, they do indicate the possible presence of pathogens of enteric origin such as *Salmonella ssp.* and *Campylobacter jejuni*. They also indicate the possible presence of gastrointestinal parasites including *Ascaris sp.*, *Giardia lamblia*, and *Cryptosporidium parvum* and enteric viruses.

Meat processing wastewaters also contain a variety of mineral elements, some of which are present in the water that is used for processing meat. In addition, water supply systems and mechanical equipment may be significant sources of metals, including copper, chromium, molybdenum, nickel, titanium, and vanadium. Manure, especially hog manure, may be significant sources of copper, arsenic, and zinc, because these constituents are commonly added to hog feed. Although pesticides such as dichcorvos, malathion, and carbaryl are commonly used in the production of meat animals to control external parasites, label-specified withdrawal periods before slaughter typically should limit concentrations to non-detectable or trace levels. Failure to observe specified withdrawal periods is an unlawful act (*7 U.S.C 136 Et. Seq*).

Table 6-3 summarizes the results of the analyses of samples of wastewater before treatment collected during sampling episodes at two hog and three cattle processing facilities. Table 6-4 presents calculated estimates of selected pollutants generated per 1,000 lb of LWK. The values listed in these two tables suggest that variation among individual facilities is not limited to the volume generated per unit of production. Average effluent concentrations for all pollutants of concern evaluated by the EPA for potential regulation are provided in Section 11.

Table 6-3. Characteristics of Wastewater Generated at Two Hog and Three Cattle Processing Facilities[a]

Parameter	Hog		Cattle	
	First Processing and Rendering	First Processing, Further Processing, and Rendering	First Processing and Rendering	First Processing, Rendering, and Hide Processing
Flow (MGD[b])	3.30	0.59	1.76	0.74-2.18
Live weight killed (1,000 lb/day)	7,449	2,012	3,942	2,443-5,645
BOD_5 (mg/L)	5,264	3,960	7,237	3,673-6,404
Total suspended solids (mg/L)	2,848	2,584	1,153	1,510-3,332
Hexane Extractables (mg/L)	158	464	146	619-3021
Total Kjeldahl nitrogen (mg/L)	330	59	306	67-78
Total phosphorus (mg/L)	104	58	35	30-58
Fecal coliform bacteria (CFU[c]/100 mL)	$2.6x10^5$	$1.6x10^6$	$7.3x10^5$	$1.2x10^6$-$1.6x10^6$

[a] Data generated during EPA sampling of MPP facilities.
[b] MGD = Million gallons per day.
[c] CFU = Colony forming units.

Table 6-4. Estimates of Pollutants Generated per Unit of Production at Two Hog and Three Cattle Processing Facilities[a]

Parameter	Hog		Cattle	
	First Processing and Rendering	**First Processing, Further Processing, and Rendering**	**First Processing and Rendering**	**First Processing, Rendering, and Hide Processing**
BOD_5 (lb/1,000 lb LWK[b])	17.8	8.9	26.3	8.6-18.9
Total suspended solids (lb/1,000 lb LWK)	9.6	5.8	4.2	3.5-9.9
Hexane extractables (lb/1,000 lb LWK)	0.54	1.04	0.53	1.44-8.94
Total Kjeldahl nitrogen (lb/1,000 lb LWK)	1.12	0.13	1.11	0.16-0.23
Total phosphorus (lb/1,000 lb LWK)	0.35	0.13	0.13	0.09-0.23
Fecal coliform bacteria (CFU[c]/1,000 lb LWK)	4.3×10^{9}	1.8×10^{10}	1.3×10^{10}	1.4×10^{10}-2.3×10^{10}

[a] Data generated during EPA sampling of MPP facilities.
[b] LWK = Live weight killed.
[c] CFU = Colony forming units.

6.2 POULTRY PROCESSING WASTES

6.2.1 Volume of Wastewater Generated

In poultry processing, water is used primarily for scalding in the process of feather removal, bird washing before and after evisceration, chilling, cleaning and sanitizing of equipment and facilities, and for cooling of mechanical equipment such as compressors and pumps. Although water also is typically used to remove feathers and viscera from production areas, overflow from scalding and chiller tanks is used.

A number of studies also have shown that the volume of water used and wastewater generated by poultry processing on a per unit of production basis (such as per bird killed) can vary substantially among processing plants. Again, some of this variation is a reflection of different levels of effort among plants to reduce their wastewater treatment costs by minimizing their water use. One study of 88 chicken processing plants found wastewater flows ranged from

4.2 to 23 gallon per bird with a mean value of 9.3 gallon per bird (USEPA, 1975). No standard deviation was reported; therefore, the distribution of individual values could not be determined. Using the reported mean live weight per bird of 3.83 pounds, 9.3 gallon per bird translates into 2,428 gallon per 1,000 lb LWK, which is significantly higher than the mean flow of 639 gallon per 1,000 lb LWK used for meat processing. For 34 turkey processing plants, the mean wastewater flow was 31.2 gallon per bird with individual plant values ranging from 9.6 to 71.4 gallon per bird. Again, no standard deviation was reported. Based on the reported mean live weight per bird of 18.2 pounds, the mean flow of 31.2 gallon per bird translates into 1,714 gallon per 1,000 lb LWK. Again, this value is substantially higher than that for meat processing, but also substantially lower than the value calculated for chickens. Two of the factors that contribute to the higher rate of wastewater generation for poultry processing are the 1) required continuous overflow from scalding tanks, and 2) use of carcass immersion in ice bath chillers with a required continuous overflow for removal of body heat after evisceration.

Table 6-5 presents the rates of wastewater generated per 1,000 lb of LWK at five broiler processing facilities sampled by the EPA. Two were first processing facilities, one was a first processing facility with on-site rendering, and two combined first processing, further processing, and rendering. As the values listed in Table 6.5 indicate, there also is a considerable degree of variation among individual poultry processing facilities. Table 6.6 presents median rates of wastewater flow per unit of production derived from MPP detailed survey responses.

Table 6-5. Rates of Wastewater Generation at Five Broiler Processing Facilities[a]

Processing Type	Gallons per 1,000 lb live weight killed
First processing	580-1,663
First processing and rendering	1,256
First processing, further processing, and rendering	1,272-2,440

[a] Data generated during EPA sampling of MPP facilities.

Table 6-6. Wastewater Volumes Produced by Poultry Facilities per Unit of Production[a]

	Process Wastewater Generated (gallons per 1,000 lbs of production unit)	
	First Processing[a]	**Further Processing[b]**
Non-small Facilities	1,323	301

[a] Median values derived from the 58 MPP detailed survey responses (as described in Section 3.2.6).
[b] Production unit for first processing operations is 1,000 lb of live weight killed (LWK). These numbers include facilities that may also generate wastewater from cutting operations.
[c] Production unit for further processing operations is 1,000 lb of finished product.
Data source: MPP detailed surveys

6.2.2 Description of Waste Constituents and Concentrations

The principal sources of wastes in poultry processing are live bird holding and receiving, killing, defeathering, eviscerating, carcass washing, chilling, cut-up, and cleanup operations. Further processing and rendering operations are also major sources of wastes. These wastes include blood not collected, feathers, viscera, soft tissue removed during trimming and cutting, bone, soil from feathers, and various cleaning and sanitizing compounds. Further processing and rendering can produce additional sources of animal fat and other soft tissue, in addition to other substances such as cooking oils.

Thus, the principal constituents of poultry processing wastewaters are a variety of readily biodegradable organic compounds, primarily fats and proteins, present in both particulate and dissolved forms. To reduce wastewater treatment requirements, poultry processing wastewaters are screened to reduce concentrations of particulate matter before treatment. An added benefit of screening is increased collection of materials and subsequent increased production of rendered by-products. Because feathers are not rendered with soft tissue, wastewater containing feathers is not commingled with other wastewater. Instead, wastewater containing feathers is screened separately and then combined with unscreened wastewater to recover soft tissue before treatment during the screening process of these mixed wastewaters.

However, poultry processing wastewaters remain high strength wastes even after screening in comparison to domestic wastewaters based on concentrations of BOD, COD, TSS, nitrogen, and phosphorus after screening. Blood not collected, solubilized fat, and feces are principal sources of BOD in poultry processing wastewaters. As with meat processing wastewaters, the efficacy of blood collection is a significant factor in determining the BOD concentration in poultry processing wastewaters.

Another significant factor in determining the BOD of poultry processing wastewaters is the degree to which manure (urine and feces), especially from receiving areas, is handled separately as a solid waste. Chicken and turkey manures have BOD concentrations in excess of 40,000 mg/kg on an as excreted basis (American Society of Agricultural Engineers, 1999). Although the cages and trucks used to transport broilers to processing plants usually are not washed, cages and trucks used to transport live turkeys to processing plants are washed to prevent transmission of disease from farm to farm. Thus, manure probably is a more significant source of wastewater BOD for turkey processing operations than for broiler processing operations.

Primarily because of immersion chilling, fat is a more significant source of BOD in poultry processing wastewaters than in meat processing wastewaters. Additional sources of BOD in poultry processing wastewaters are feather and skin oils desorbed during scalding for feather removal. Thus, the oil and grease content of poultry processing wastewaters typically is higher than that in meat processing wastewaters.

Blood not collected, as well as urine and feces, also are significant sources of nitrogen in poultry processing wastewaters. The principal form of nitrogen in these wastewaters before treatment is as organic nitrogen with some ammonia nitrogen produced by the microbially mediated mineralization of organic nitrogen during collection. Nitrite and nitrate nitrogen generally are present only in trace concentrations, less than 1 mg/L. The phosphorus in poultry processing wastewaters is primarily from blood, manure, and cleaning and sanitizing compounds such as trisodium phosphate (trisodium phosphate tribasic), and trisodium phosphate in detergents.

Due to the presence of manure in poultry processing wastewaters and commingling of processing and sanitary wastewaters after screening, and dissolved air flotation of the former, densities of the total and fecal coliform and fecal streptococcus groups of bacteria generally are on the order of several million colony-forming units per 100 milliliters (cfu/100 mL). As discussed earlier, members of these groups of microorganisms generally are not pathogenic. They do, however, indicate the possible presence of pathogens of enteric origin, such as *Salmonella sp*. and *Campylobacter jejuni*, gastrointestinal parasites, and pathogenic enteric viruses. *Giardia lamblia*, and *Cryptosporidium parvum* are not of concern in poultry processing wastewaters.

Poultry processing wastewaters also contain a variety of mineral elements, some of which are present in the potable water used for processing poultry. Water supply systems and mechanical equipment may be significant sources of metals including copper, chromium, molybdenum, nickel, titanium, and vanadium. In addition, manure is a significant source of arsenic and zinc. Although pesticides such as carbaryl, also are commonly used in the production of poultry to control external parasites, label-specified withdrawal periods before slaughter typically should limit concentrations to non-detectable or trace levels. Failure to observe specified withdrawal periods is an unlawful act (7 U.S.C. 136 et seq.).

Table 6-7 summarizes the results of the analyses of samples of wastewater before treatment collected during sampling episodes at the five broiler processing facilities described earlier. Table 6-8 presents calculated estimates of selected pollutants generated per 1,000 lb of LWK. The values listed in these two tables suggest that variation among individual broiler processing facilities also is not limited to the volume generated per unit of production. Average effluent concentrations for all pollutants of concern evaluated by the EPA for potential regulation are provided in Section 11.

Table 6-7. Characteristics of Wastewater Generated at Five Broiler Processing Facilities[a]

Parameter	First Processing	Further Processing and Rendering	First Processing, Further Processing, and Rendering
Flow (MGD[b])	0.60-1.10	1.29	1.24-1.97
Live weight kill (1,000 lb/day)	661-1,025	1,026	808-974
BOD_5 (mg/L)	948-1,856	1,680	1,488-2,166
Total suspended solids (mg/L)	714-776	1,040	510-1,526
Hexane extractables (mg/L)	487-1,501	430	243-685
Total Kjeldahl nitrogen (mg/L)	14-34	102	65-112
Total phosphorus (mg/L)	6-11	17	15-48
Fecal coliform bacteria (CFU[c]/100 mL)	2.6×10^5-1.2×10^6	1.6×10^5	8.5×10^5-1.6×10^6

[a] Data generated during EPA sampling of MPP facilities.
[b] MGD = Million gallons per day.
[c] CFU = colony forming units.

Table 6-8. Pollutant Generation per Unit of Production in Broiler Processing[a]

Parameter	Broiler		Turkey
	First Processing	Further Processing and Rendering	First Processing, Further Processing, and Rendering
	Average	Average[b]	Average
BOD_5 (lb/1,000 lb LWK[b])	8.4-12.11	16.2	14.5-40.5
Total suspended solids (lb/1,000 lb LWK)	3.5-9.1	10.0	9.5-15.2
Hexane Extractables (lb/1,000 lb LWK)	1.78-2.20	4.14	4.54-6.68
Total Kjeldahl nitrogen (lb/1,000 lb LWK)	0.15-0.18	0.98	1.09-1.22
Total phosphorus (lb/1,000 lb LWK)	0.05-0.08	0.16	0.28-0.47
Fecal coliform bacteria (CFU[c]/1,000 lb LWK)	1.6×10^{10}-2.7×10^{10}	7.6×10^{10}	7.7×10^{10}-7.9×10^{10}

[a] Data generated during EPA sampling of MPP facilities.
[b] LWK = Live weight killed.
[c] CFU = Colony forming units.

6.3 RENDERING WASTEWATER GENERATION AND CHARACTERISTICS

The slaughter of livestock and poultry produces a considerable amount of inedible viscera and other solid wastes, including feathers from poultry and hair from hogs. Inedible viscera and other soft tissue, fat, and bone, which are collected as solid wastes and removed from wastewater by screening, are converted by rendering into valuable byproducts such as meat meal and meat and bone meal. In the rendering process, these materials are cooked in their own moisture and fat in vented steam-jacketed vessels until the moisture has evaporated. Then, as much fat as possible is removed and the solid residue is passed through a screw press, dried, and granulated or ground into a meal for sale as a livestock or poultry or pet food ingredient. In some situations, dissolved air flotation (DAF) solids are disposed of by rendering, although DAF solids reduce the quality of rendered products, especially if metal salts are used for flocculation/coagulation prior to DAF.

Rendering operations also may include blood drying to produce blood meal for sale as a feed ingredient or fertilizer. They also may include the hydrolysis of hair or feathers for the production of livestock and poultry feed ingredients. Typically, blood from poultry processing operations is combined with feathers to increase the value of the resulting feather meal as a source of protein.

Rendering may be performed at the same site as other meat or poultry processing operations or at a separate location, usually by an independent entity. When rendering is performed in conjunction with other meat or poultry processing operations, wastes from locations without on-site rendering also may be processed.

6.3.1 Volume of Wastewater Generated

Rendering operations are intensive users of water and significant generators of wastewater. Water is used throughout the rendering process, including for raw material cooking and sterilization, condensing cooking vapors, plant cleanup, truck and barrel washing when materials from off-site locations are being processed, odor control, and steam generation (USEPA, 1975). Most of these activities also generate wastewater. According to the National Rendering Association (2000), rendering plants produce approximately one-half ton (120 gallons) of water for each ton of rendered material. Variations in wastewater flow per unit of raw material processed are largely attributable to the type of condensers used for condensing the cooking vapors and, to a lesser extent, to the initial moisture content of the raw material.

Based on a survey of National Rendering Association (NRA) members, an average size rendering plant generates about 215,000 gallons per day of process wastewater and an average of 34,000 gallons per day from other sources (National Rendering Association, 2000). The NRA estimates that the average plant discharges about 243,300 gallons per day or 169 gallons per minute.

The major sources of wastewater at rendering plants are produced from raw material receiving operations (especially when materials from off-site locations are being processed), condensing cooking vapors, drying, plant cleanup, and truck and barrel washing (USEPA, 1975). Condensates formed during raw material sterilization and drying are the largest contributors to the total wastewater in terms of volume and pollutant load (Metzner and Temper, 1990). At those rendering plants where hide curing is also performed as an ancillary operation, additional volumes of raw waste are generated, although those operations are not covered by this rule. Note, however, that hide processing wastewaters may be commingled with MPP wastewaters prior to treatment, and the commingled wastewater would be subject to this rule.

Condensates recovered from cooking and drying processes contain high concentrations of volatile organic acids, amines, mercaptans, and other odorous compounds. Thus, rendering plant condensers can be sources of significant emissions of noxious odors to the atmosphere if water scrubbing is not used for emissions control. There is little increase in final effluent volume when water scrubbing is used, because recycled final effluent is used for scrubber operation. Up to 75 percent of a plant’s final effluent may be used (USEPA, 1975).

Liquid drainage from raw materials receiving areas can contribute significantly to the total raw waste load (USEPA, 1975). Large amounts of raw materials commonly accumulate in receiving areas (in bins or on floors). Fluids from these raw materials drain off and enter the internal plant sewers (USEPA, 1975). At rendering plants that process poultry, drainage of liquids can be significant because of the use of fluming to transport feathers and viscera in the processing plant. In such plants, liquid drainage may account for approximately 20 percent of the original raw material weight.

The other important source of wastewater from rendering operations is water used for cleaning equipment and facilities, the cleanup of spills, and trucks when materials are received from off-site locations for rendering. Cleanup of rendering equipment and facilities is less intensive than that in processing facilities and usually occurs only once per day, even though rendering usually is a 24-hour operation and commonly occurs on a seven day per week schedule. The wastewater generated during cleanup operations usually accounts for about 30 percent of total rendering plant wastewater flow (USEPA, 1975).

Approximately 30 percent of the total raw BOD waste load originates in the cooking and drying process (USEPA, 1975). Factors such as rate of cooking, speed of agitation, cooker overloading, foaming, and presence of traps can result in volume and composition differences among different rendering plants. Other important sources of process wastewater include plant and truck wash-down activities, and the cleanup of spills.

Table 6-9 presents the rates of wastewater flow per 1,000 lb of rendered product (RP) at one broiler, three hog, and three cattle processing facilities with on-site rendering sampled by EPA. The broiler, two of the hog, and all three of the cattle processing facilities were first processing facilities while the remaining hog processing facility combined first and further processing. Again, the degree of variation among facilities is noteworthy. Table 6-10 presents median rates of wastewater flow per unit of production derived from MPP detailed survey responses.

Table 6-9. Rates of Wastewater Generation at Broiler, Hog, and Cattle Processing Facilities with On-site Rendering[a]

Meat type	Gallons/1,000 lb of rendered product
Broiler	200
Hogs	211-302
Cattle	273-1,374

[a] Data generated during EPA sampling of MPP facilities.

Table 6-10. Wastewater Volumes Produced by Rendering Operations per Unit of Production

	Process Wastewater Generated (gallons per 1,000 lbs of raw material)
	Rendering[a]
Non-small facilities	578

[a] Median values derived from the 58 MPP detailed survey responses (as described in Section 3.2.6).
[b] These estimates reflects wastewater generated by on-site and off-site (independent) renderers.

6.3.2 Description of Waste Constituents and Concentrations

The principal constituents in wastewaters from rendering operations are the same as those in meat and poultry processing wastewaters. In addition, it appears that there is little difference in rendering wastewater constituents or concentrations attributable to the source of materials being processed. A 1975 survey found that the range and average of BOD wastewater values for plants processing more than 50 percent poultry by-products could not be differentiated from those plants processing less than 50 percent poultry by-products (USEPA, 1975). Additionally, the study found that plant size does not affect the levels of pollutants in the waste stream. However, management and operating variables, such as rate of cooking, speed of agitation, cooker overloading, foaming, and presence or absence of traps, were found to influence both wastewater volume and the concentrations of various wastewater constituents, as would be expected.

Another factor affecting the composition of rendering process wastewaters is the degree of decomposition that has occurred before rendering (USEPA, 1975). In warm weather, significant decomposition can occur, especially with materials from off-site sources. One result is increased wastewater ammonia nitrogen concentrations during summer months.

Table 6-11 provides a sense of the significance of various sources of wastewater from rendering operations relative to typical analyte composition before treatment. In this table, concentrations found in samples collected from a continuous dry rendering plant in Columbus, Ohio are presented (Hansen and West, 1992). Samples from blood, cooker condensate, and wash-up water were analyzed. The cooker condensate was mostly composed of condensed volatile fats and oils with some ammonia. The wash-up water consisted of plant cleanup water mixed with drainage from the raw product storage hopper. (The relative proportions were not measured.)

Table 6-11. Pollutant Concentrations for a Dry Continuous Rendering Plant

Parameter	Raw Blood[a] (mg/L)	Condensate Batch 1[a,b] (mg/L)	Condensate Batch 2[a,b] (mg/L)	Wash-up water[c] (mg/L)
Total COD	150,000	6,000	2,400	7,600
Soluble COD	136,000	6,000	2,400	3,200
Total Kjeldahl nitrogen (TKN-N)	16,500	740	430	270
Ammonia nitrogen	3,500	740	430	40
*COD: TKN	9.1	8.1	5.6	28.1
Total Phosphorus (P)	183	<4	<4	15.1
*COD: P	820	>1500	>600	503
Freon extractables (FOG)	620	260	110	35
Potassium	793	<6	<6	20.9
Calcium	55	<1	<1	26.4
Magnesium	27	<1	<1	7.3
Iron	164	2	2	9.4
Sodium	818	0.1	0.1	37.1
Copper	0.7	<0.2	<0.2	0.1
Zinc	1.3	<0.15	<0.15	0.46
Manganese	0.05	0.05	0.05	0.01
Lead	<0.6	<3	<3	<1.3
Chromium	0.3	<0.2	<0.2	0.12
Cadmium	0.05	<0.01	<0.01	<0.04
Nickel	<0.2	<1	<1	<0.4
Cobalt	<0.02	<0.01	<0.01	<0.04
Sulfate (SO_4-S)	300	<2	<2	4.6
Total Chloride	1700	<2	<2	86

[a] Each value is the mean of three samples analyzed in duplicate.
[b] The strength of condensate varied from winter to summer; however, only condensate collected during the summer was used in these studies. Cold ambient temperatures around the forced air condensers affected the COD strength of the cooker condensate. The COD strength of the blood and wash-up water was similar for both batches; therefore, data for each batch is not included separately.
[c] Each point is the mean of duplicate analyses of one sample.
[d] < and > symbols both indicate the limits of the analyses were exceeded.
* These parameters are ratios and have no units.
Source: Hansen and West, 1992

Although the blood accounted for only a small percentage of the total volume of wastewater, it clearly is a highly significant source of COD, TKN, ammonia nitrogen, and grease in rendering plant wastewater.

Table 6-12 summarizes the results of the analyses of samples of wastewater before treatment collected during sampling episodes at one broiler and one cattle processing facility with on-site rendering described earlier. Average effluent concentrations for all pollutants of concern evaluated by the EPA for potential regulation are provided in Section 11.

In 2000, the NRA collected data from its membership to provide a general characterization of rendering process wastewaters. Table 6-13 presents the results of this survey. The data are only for wastewater generated and final effluent characteristics, and do not cover specific sources of generated wastewater. The final effluent data indicate pollutant loads after treatment has been applied. The NRA did not report data on metals in generated wastewater or on nutrients in generated or discharged wastewater.

In Table 6-14, calculated estimates of selected pollutants generated per 1,000 lb of rendered product are summarized. Again, the values listed in these two tables indicate that there is a considerable degree of variation among individual facilities.

6.4 CONCLUSIONS

The number of meat and poultry processing facilities that were sampled by the EPA to characterize the volumes of wastewater generated on a normalized per unit of production basis and the concentrations of pollutants present clearly represent only a small fraction of the number of facilities in the MPP industry. However, the results obtained in these sample episodes in combination with other sources of information suggests that there is a considerable degree of variation among facilities even within each segment of the industry in both the volume of wastewater generated per unit of production and the concentrations of specific pollutants. The sampling episode results demonstrate that the differences between two facilities with the same

Table 6-12. Characteristics of Wastewaters Generated at Broiler and Cattle On-Site Rendering Operations[a]

Parameter	Broiler	Cattle
Flow (MGD[b])	0.29	0.15
Rendered product (1,000 lb/day)	1442	112
BOD_5 (mg/L)	1,984	3,870
Total suspended solids (mg/L)	3,248	837
Hexane extractables (mg/L)	1,615	362
Total Kjeldahl nitrogen (mg/L)	180	141
Total phosphorus (mg/L)	38	58
Fecal coliform bacteria (CFU[c]/100 ml)	1.2×10^6	1.2×10^6

[a] Data generated during the EPA sampling of MPP facilities.
[b] MGD = Million gallons per day.
[c] CFU = colony forming units.

Table 6-13. Wastewater Characterization of "Typical" National Rendering Association (NRA) Member Render Plant[a]

Parameter	Generated Wastewater (mg/L)	Discharged Wastewater (mg/L)
Chemical oxygen demand (mg/L)	123,000	8,000
Biochemical oxygen demand (mg/L)	80,000	5,100
Total suspended solids (mg/L)	8,400	268
Fat and other greases (mg/L)	3,200	116
Metals (average zinc) (mg/L)	NA	0.68
Fecal coliform bacteria (CFU[c]/100 ml)	2.5×10^8 cfu/mL	4.5×10^4 cfu/mL

[a] NRA, 2000.
[b] NA = not available.
[c] CFU = colony forming units.

Table 6-14. Estimates of Pollutants Generated per Unit of Production in On-Site Broiler and Cattle Rendering Operations[a]

Parameter	Broiler	Cattle
BOD_5 (lb/1,000 lb RP[b])	3.31	44.4
Total suspended solids (lb/1,000 lb RP)	5.42	9.60
Hexane extractables (lb/1,000 lb RP)	2.70	4.15
Total Kjeldahl nitrogen (lb/1,000 lb RP)	0.30	1.62
Total phosphorus (lb/1,000 lb RP)	0.06	0.67
Fecal coliform bacteria (CFU[c]/1,000 lb RP)	9.1×10^9	6.2×10^{10}

[a] Data generated during the EPA sampling of MPP facilities.
[b] RP = rendered product.
[c] CFU = colony forming units.

activity such as only first processing of broilers or first processing of cattle with on-site rending and hide processing can be substantial. This suggests that differences in-plant waste management practices, such as minimizing water use and separate collection of solid wastes, are critical factors in determining the volume of wastewater and the masses of individual pollutants generated per unit of production. Thus, it seems reasonable to conclude that any mean or median values characterized as typical values probably will describe the wastewater generated at a relatively small fraction of the total number of facilities in each segment of the MPP industry. However, it also seems reasonable to conclude that the impact of this variability will be limited to the cost of wastewater treatment to comply with the final rule promulgated and not the ability to comply. This variability also suggests that estimates of compliance costs for existing facilities may be reduced by implementation of more effective in-plant waste management practices.

6.5 REFERENCES

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