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Manure Production and Characteristics

American Society of Agricultural Engineers

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Manure Production and Characteristics

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1 Purpose and scope

1.1 Data on livestock manure production and characteristics are presented to assist in the planning, design and operation of manure collection, storage, pretreatment and utilization systems for livestock enterprises.

1.2 These data are combined from a wide base of published and unpublished information on livestock manure production and characterization. Users of this information should recognize that the mean values for each parameter are determined by an arithmetic average consisting of one data point per reference source per year. The values represent fresh (as voided) feces and urine. Actual values vary due to differences in animal diet, age, usage, productivity and management. Whenever site specific data are available or actual sample analyses can be performed, such information should be considered in lieu of the mean values presented here.

Table 1 – Fresh manure production and characteristics per 1 000 kg live animal mass per day

			Animal Type[†]										
Parameter	Units*		Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Total manure[‡]	kg	mean[§]	86	58	62	84	40	41	51	64	85	47	110
		std. deviation	17	17	24	24	11	8.6	7.2	19	13	13	**
Urine	kg	mean	26	18	**	39	15	**	10	**	**	**	**
		std. deviation	4.3	4.2	**	4.8	3.6	**	0.74	**	**	**	**
Density	kg/m^3	mean	990	1 000	1 000	990	1 000	1 000	1 000	970	1 000	1 000	**
		std. deviation	63	75	**	24	64	**	93	39	**	**	**
Total solids	kg	mean	12	8.5	5.2	11	11	13	15	16	22	12	31
		std. deviation	2.7	2.6	2.1	6.3	3.5	1.0	4.4	4.3	1.4	3.4	15
Volatile solids	kg	mean	10	7.2	2.3	8.5	9.2	**	10	12	17	9.1	19
		std. deviation	0.79	0.57	**	0.66	0.31	**	3.7	0.84	1.2	1.3	**
Biochemical oxygen demand, 5-day	kg	mean	1.6	1.6	1.7	3.1	1.2	**	1.7	3.3	**	2.1	4.5
		std. deviation	0.48	0.75	**	0.72	0.47	**	0.23	0.91	**	0.46	**
Chemical oxygen demand	kg	mean	11	7.8	5.3	8.4	11	**	**	11	16	9.3	27
		std. deviation	2.4	2.7	**	3.7	2.5	**	**	2.7	1.8	1.2	**
pH		mean	7.0	7.0	8.1	7.5	**	**	7.2	6.9	**	**	**
		std. deviation	0.45	0.34	**	0.57	**	**	**	0.56	**	**	**
Total Kjeldahl nitrogen[‖]	kg	mean	0.45	0.34	0.27	0.52	0.42	0.45	0.30	0.84	1.1	0.62	1.5
		std. deviation	0.096	0.073	0.045	0.21	0.11	0.12	0.063	0.22	0.24	0.13	0.54
Ammonia nitrogen	kg	mean	0.079	0.086	0.12	0.29	**	**	**	0.21	**	0.080	**
		std. deviation	0.083	0.052	0.016	0.10	**	**	**	0.18	**	0.018	**
Total phosphorus	kg	mean	0.094	0.092	0.066	0.18	0.087	0.11	0.071	0.30	0.30	0.23	0.54
		std. deviation	0.024	0.027	0.011	0.10	0.030	0.016	0.026	0.081	0.053	0.093	0.21
Orthophosphorus	kg	mean	0.061	0.030	**	0.12	0.032	**	0.019	0.092	**	**	0.25
		std. deviation	0.005 8	**	**	**	0.014	**	0.007 1	0.016	**	**	**
Potassium	kg	mean	0.29	0.21	0.28	0.29	0.32	0.31	0.25	0.30	0.40	0.24	0.71
		std. deviation	0.094	0.061	0.10	0.16	0.11	0.14	0.091	0.072	0.064	0.080	0.34
Calcium	kg	mean	0.16	0.14	0.059	0.33	0.28	**	0.29	1.3	0.41	0.63	**
		std. deviation	0.059	0.11	0.049	0.18	0.15	**	0.11	0.57	**	0.34	**
Magnesium	kg	mean	0.071	0.049	0.033	0.070	0.072	**	0.057	0.14	0.15	0.073	**
		std. deviation	0.016	0.015	0.023	0.035	0.047	**	0.016	0.042	**	0.007 1	**
Sulfur	kg	mean	0.051	0.045	**	0.076	0.055	**	0.044	0.14	0.085	**	**
		std. deviation	0.010	0.005 2	**	0.040	0.043	**	0.022	0.066	**	**	**
Sodium	kg	mean	0.052	0.030	0.086	0.067	0.078	**	0.036	0.10	0.15	0.066	**
		std. deviation	0.026	0.023	0.063	0.052	0.027	**	**	0.051	**	0.012	**
Chloride	kg	mean	0.13	**	**	0.26	0.089	**	**	0.56	**	**	**
		std. deviation	0.039	**	**	0.052	**	**	**	0.44	**	**	**
Iron	g	mean	12	7.8	0.33	16	8.1	**	16	60	**	75	**
		std. deviation	6.6	5.9	**	9.7	3.2	**	8.1	49	**	28	**
Manganese	g	mean	1.9	1.2	**	1.9	1.4	**	2.8	6.1	**	2.4	**
		std. deviation	0.75	0.51	**	0.74	1.5	**	2.1	2.2	**	0.33	**

Table 1 – Fresh manure production and characteristics per 1 000 kg live animal mass per day (continued)

Parameter	Units*		Animal Type†										
			Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Boron	g	mean	0.71	0.88	**	3.1	0.61	**	1.2	1.8	**	**	**
		std. deviation	0.35	0.064	**	0.95	0.30	**	0.48	1.7	**	**	**
Molybdenum	g	mean	0.074	0.042	**	0.028	0.25	**	0.083	0.30	**	**	**
		std. deviation	0.012	**	**	0.030	0.38	**	0.033	0.057	**	**	**
Zinc	g	mean	1.8	1.1	13	5.0	1.6	**	2.2	19	3.6	15	**
		std. deviation	0.65	0.43	**	2.5	1.0	**	2.1	33	**	12	**
Copper	g	mean	0.45	0.31	0.048	1.2	0.22	**	0.53	0.83	0.98	0.71	**
		std. deviation	0.14	0.12	**	0.84	0.066	**	0.39	0.84	**	0.10	**
Cadmium	g	mean	0.003 0	**	**	0.027	0.007 2	**	0.005 1	0.038	**	**	**
		std. deviation	**	**	**	0.028	**	**	**	0.032	**	**	**
Nickel	g	mean	0.28	**	**	**	**	**	0.62	0.25	**	**	**
		std. deviation	**	**	**	**	**	**	**	**	**	**	**
Lead	g	mean	**	**	**	0.084	0.084	**	**	0.74	**	**	**
		std. deviation	**	**	**	0.012	**	**	**	**	**	**	**
Total coliform bacteria	colonies#	mean	1 100	63	**	45	20	**	490	110	**	**	**
		std. deviation	2 800	59	**	33	26	**	490	100	**	**	**
Fecal coliform bacteria	colonies	mean	16	28	**	18	45	**	0.092	7.5	**	1.4	180
		std. deviation	28	27	**	12	27	**	0.029	2.0	**	**	180
Fecal streptococcus bacteria	colonies	mean	92	31	**	530	62	**	58	16	**	**	590
		std. deviation	140	45	**	290	73	**	59	7.2	**	**	**

*All values wet basis.
†Differences within species according to usage exist, but sufficient fresh manure data to list these differences was not found. Typical live animal masses for which manure values represent are: dairy, 640 kg; beef, 360 kg; veal, 91 kg; swine, 61 kg; sheep, 27 kg; goat, 64 kg; horse, 450 kg; layer, 1.8 kg; broiler, 0.9 kg; turkey, 6.8 kg; and duck, 1.4 kg.
‡Feces and urine as voided.
§Parameter means within each animal species are comprised of varying populations of data. Maximum numbers of data points for each species are: dairy, 85; beef, 50; veal, 5; swine, 58; sheep, 39; goat, 3; horse, 31; layer, 74; broiler, 14; turkey, 18; and duck, 6.
‖All nutrients and metals values are given in elemental form.
#Mean bacteria colonies per 1 000 kg animal mass multiplied by 10^{10}. Colonies per 1 000 kg animal mass divided by kg total manure per 1 000 kg animal mass multiplied by density kg/m^3 equals colonies per m^3 of manure.
**Data not found.

Table 2 – Fresh manure production and characteristics per 1,000 lb live animal mass per day

Parameter	Units*		Animal Type†										
			Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Total manure‡	lb	mean§	86	58	62	84	40	41	51	64	85	47	110
		std. deviation	17	17	24	24	11	8.6	7.2	19	13	13	**
Urine	lb	mean	26	18	**	39	15	**	10	**	**	**	**
		std. deviation	4.3	4.2	**	4.8	3.6	**	0.74	**	**	**	**
Density	lb/ft^3	mean	62	63	62	62	64	63	63	60	63	63	**
		std. deviation	4.0	4.7	**	1.5	4.0	**	5.8	2.4	**	**	**
Total solids	lb	mean	12	8.5	5.2	11	11	13	15	16	22	12	31
		std. deviation	2.7	2.6	2.1	6.3	3.5	1.0	4.4	4.3	1.4	3.4	15
Volatile solids	lb	mean	10	7.2	2.3	8.5	9.2	**	10	12	17	9.1	19
		std. deviation	0.79	0.57	**	0.66	0.31	**	3.7	0.84	1.2	1.3	**
Biochemical oxygen demand, 5-day	lb	mean	1.6	1.6	1.7	3.1	1.2	**	1.7	3.3	**	2.1	4.5
		std. deviation	0.48	0.75	**	0.72	0.47	**	0.23	0.91	**	0.46	**
Chemical oxygen demand	lb	mean	11	7.8	5.3	8.4	11	**	**	11	16	9.3	27
		std. deviation	2.4	2.7	**	5.3	2.5	**	**	2.7	18	1.2	**
pH		mean	7.0	7.0	8.1	7.5	**	**	7.2	6.9	**	**	**
		std. deviation	0.45	0.34	**	0.57	**	**	**	0.56	**	**	**
Total Kjeldahl nitrogen‖	lb	mean	0.45	0.34	0.27	0.52	0.42	0.45	0.30	0.84	1.1	0.62	1.5
		std. deviation	0.096	0.073	0.045	0.21	0.11	0.12	0.063	0.22	0.24	0.13	0.54
Ammonia nitrogen	lb	mean	0.079	0.086	0.12	0.29	**	**	**	0.21	**	0.080	**
		std. deviation	0.083	0.052	0.016	0.10	**	**	**	0.18	**	0.018	**
Total phosphorus	lb	mean	0.094	0.092	0.066	0.18	0.087	0.11	0.071	0.30	0.30	0.23	0.54
		std. deviation	0.024	0.027	0.011	0.10	0.030	0.016	0.026	0.081	0.053	0.093	0.21

Table 2 – Fresh manure production and characteristics per 1,000 lb live animal mass per day (continued)

Parameter	Units*		Animal Type†										
			Dairy	Beef	Veal	Swine	Sheep	Goat	Horse	Layer	Broiler	Turkey	Duck
Orthophosphorus	lb	mean	0.061	0.030	**	0.12	0.032	**	0.019	0.092	**	**	0.25
		std. deviation	0.058	**	**	**	0.014	**	0.0071	0.016	**	**	**
Potassium	lb	mean	0.29	0.21	0.28	0.29	0.32	0.31	0.25	0.30	0.40	0.24	0.71
		std. deviation	0.094	0.061	0.10	0.16	0.11	0.14	0.091	0.072	0.064	0.080	0.34
Calcium	lb	mean	0.16	0.14	0.059	0.33	0.28	**	0.29	1.3	0.41	0.63	**
		std. deviation	0.059	0.11	0.049	0.18	0.15	**	0.11	0.57	**	0.34	**
Magnesium	lb	mean	0.071	0.049	0.033	0.070	0.072	**	0.057	0.14	0.15	0.073	**
		std. deviation	0.016	0.015	0.023	0.035	0.047	**	0.016	0.042	**	0.0071	**
Sulfur	lb	mean	0.051	0.045	**	0.076	0.055	**	0.044	0.14	0.085	**	**
		std. deviation	0.010	0.0052	**	0.040	0.043	**	0.022	0.066	**	**	**
Sodium	lb	mean	0.052	0.030	0.086	0.067	0.078	**	0.036	0.10	0.15	0.066	**
		std. deviation	0.026	0.023	0.063	0.052	0.027	**	**	0.051	**	0.012	**
Chloride	lb	mean	0.13	**	**	0.26	0.089	**	**	0.56	**	**	**
		std. deviation	0.039	**	**	0.052	**	**	**	0.44	**	**	**
Iron	lb	mean	0.012	0.0078	0.00033	0.016	0.0081	**	0.016	0.060	**	0.075	**
		std. deviation	0.0066	0.0059	**	0.0097	0.0032	**	0.0081	0.049	**	0.028	**
Manganese	lb	mean	0.0019	0.0012	**	0.0019	0.0014	**	0.0028	0.0061	**	0.0024	**
		std. deviation	0.00075	0.00051	**	0.00074	0.0015	**	0.0021	0.0022	**	0.00033	**
Boron	lb	mean	0.00071	0.00088	**	0.0031	0.00061	**	0.0012	0.0018	**	**	**
		std. deviation	0.00035	0.000064	**	0.00095	0.00030	**	0.00048	0.0017	**	**	**
Molybdenum	lb	mean	0.000074	0.000042	**	0.000028	0.00025	**	0.000083	0.00030	**	**	**
		std. deviation	0.000012	**	**	0.000030	0.00038	**	0.000033	0.000057	**	**	**
Zinc	lb	mean	0.0018	0.0011	0.013	0.0050	0.0016	**	0.0022	0.019	0.0036	0.015	**
		std. deviation	0.00065	0.00043	**	0.0025	0.0010	**	0.0021	0.033	**	0.012	**
Copper	lb	mean	0.00045	0.00031	0.000048	0.0012	0.00022	**	0.00053	0.00083	0.00098	0.00071	**
		std. deviation	0.00014	0.00012	**	0.00084	0.000066	**	0.00039	0.00084	**	0.00010	**
Cadmium	lb	mean	0.0000030	**	**	0.000027	0.0000072	**	0.0000051	0.000038	**	**	**
		std. deviation	**	**	**	0.000028	**	**	**	0.000032	**	**	**
Nickel	lb	mean	0.00028	**	**	**	**	**	0.00062	0.00025	**	**	**
		std. deviation	**	**	**	**	**	**	**	**	**	**	**
Lead	lb	mean	**	**	**	0.000084	0.000084	**	**	0.00074	**	**	**
		std. deviation	**	**	**	0.000012	**	**	**	**	**	**	**
Total coliform bacteria	colonies#	mean	500	29	**	21	9.0	**	220	50	**	**	**
		std. deviation	1300	27	**	15	12	**	220	46	**	**	**
Fecal coliform bacteria	colonies	mean	7.2	13	**	8.0	20	**	0.042	3.4	**	0.62	81
		std. deviation	13	12	**	5.4	12	**	0.013	0.91	**	**	81
Fecal streptococcus bacteria	colonies	mean	42	14	**	240	28	**	26	7.4	**	**	270
		std. deviation	63	21	**	130	33	**	27	3.3	**	**	**

*All values wet basis.

†Differences within species according to usage exist, but sufficient fresh manure data to list these differences was not found. Typical live animal masses for which manure values represent are: dairy, 1400 lb; beef, 800 lb; veal, 200 lb; swine, 135 lb; sheep, 60 lb; goat, 140 lb; horse, 1000 lb; layer, 4 lb; broiler, 2 lb; turkey, 15 lb; and duck, 3 lb.

‡Feces and urine as voided.

§Parameter means within each animal species are comprised of varying populations of data. Maximum numbers of data points for each species are: dairy, 85; beef, 50; veal, 5; swine, 58; sheep, 39; goat, 3; horse, 31; layer, 74; broiler, 14; turkey, 18; and duck, 6.

‖All nutrients and metals values are given in elemental form.

#Mean bacteria colonies per 1,000 lb animal mass multiplied by 10^{10}. Colonies per 1,000 lb animal mass divided by lb total manure per 1,000 lb animal mass multiplied by density (lb/ft^3) equals colonies per ft^3 of manure.

**Data not found.