SWINE UPDATE

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Animal Sciences & Industry

Nutrient Composition of Kansas Swine Lagoons, Hoop Barn Manure

by Joel DeRouchey

Nutrient reference values provide average concentrations of various types of manure from different livestock species. Published values are a source of information producers can use to determine the amount of land needed for manure application or for comparison to their on-farm manure analysis.

These reference values represent manure samples from across the United States gathered over the past two decades. But the majority of these published values may not reflect manure nutrient profiles from Kansas swine operations or recent changes in management practices, such as phase feeding, use of phytase, reduced particle size, or differences in nutrient concentrations associated with different types of production phases or manure handling systems. In addition, published values do not account for differences that may occur with the season of the year, and therefore may not present an accurate nutrient profile for producers. The objective of our study was to determine the impacts of production phase and season of the year on nutrient concentration of swine lagoons and hoop barn manure from Kansas swine operations.

Methods

Lagoons. Samples from five types of production systems were taken six times in the year 2000 to determine changes in nutrient and mineral concentrations. The operations were classified as sow, nursery, wean-to-finish, finish, and farrow-to-finish, with a total of 9, 8, 7, 10, and 8 lagoons sampled from each phase of production, respectively. Classification was based on the type of facility sending effluent into the lagoon. Lagoons were sampled in February, April, June, August, October, and December. A uniform lagoon sampling technique was used at all locations.

Hoop barns. Samples from six hoop barn sites were collected at the same time as lagoons. All manure from the production sites used in this study originated from growing and/or finishing pigs. A least five samples were collected approximately 18 inches from the outside of the manure pile to reduce the incidence of weather effects. Manure piles sampled throughout the year ranged from those that had just been removed from the hoop barn, to manure piles that had been stored for more than a year.

Results

Lagoon Concentration by Production Phase. Nutrient concentrations from lagoons on wean-to-finish and finishing operations were higher for the majority of nutrients compared to sow and farrow-to-finish operations (Table 1). Samples from nursery lagoons usually had intermediate values, except for trace minerals, of which they had the highest concentrations.

For total nitrogen, lagoons from finishing and wean-to-finish facilities had greater concentrations ($P < .05$) compared to sow and farrow-to-finish lagoons. In addition, lagoons from sow and farrow-to-finish operations had approximately 39% and 48% less total nitrogen respectively compared to nursery lagoons, although the differences were not significant ($P > .05$). For ammonium nitrogen, farrow-to-finish lagoons had lower ($P < .05$) levels than wean-to-finish and finishing lagoons. Furthermore, the level of nitrate nitrogen was less than 1 ppm for all production phases, indicating that nitrates are of little concentration in the liquid portion sampled from the lagoons.

Phosphorus concentrations in farrow-to-finish lagoons were lower ($P < .05$) by approximately 65 percent compared to lagoons from wean-to-finish operations. Although not significantly different ($P > .05$), phosphorus concentrations from nursery (223 ppm) and finishing (246 ppm) lagoons were higher, while concentrations from sow farms had levels (141 ppm) below that of the overall average of 203 ppm for all samples. Sow lagoons contained lower ($P < .05$) potassium concentrations than wean-to-finish and finishing lagoons, while levels in nursery and farrow-to-finish lagoons were intermediate. Furthermore, farrow-to-finish lagoons had lower ($P < .05$) concentrations of calcium than nursery, wean-to-finish, and finishing lagoons, while sow lagoons had lower ($P < .05$) levels than finishing lagoons.

For sodium, no differences between phases of production were detected. However, sow lagoons had a lower concentration ($P < .05$) of chloride and magnesium than wean-to-finish and finishing lagoons, with nursery and farrow-to-finish lagoons having intermediate concentrations. Sulfur concentrations were dramatically reduced ($P < .05$) in lagoons from sow and farrow-to-finish operations compared to that of the other three types of production phases.

The trace minerals (copper, zinc, iron, and manganese), were lowest in sow and farrow-to-finish lagoons compared to the other production phases. In addition, concentrations of all minor nutrients, except manganese, were the highest in nursery lagoons. For copper and iron concentrations, nursery lagoons had a higher level ($P < .05$) compared to sow and farrow-to-finish lagoons. The zinc concentration was higher in nursery lagoons ($P < .05$) than all other phases of production—approximately 59% higher (40.7 vs. 16.8 ppm) than the combined mean of all phases. For manganese, sow and farrow-to-finish lagoons contained lower ($P < .05$) concentrations compared to lagoons from the other three production phases.

Lagoon Concentration by Season. For nitrogen characteristics, the amount of ammonium and total nitrogen concentrations decreased (linear, $P < .05$) from February until December (Table 2). But the largest decline occurred between June and August, with a moderate increase from October to December. The concentration of organic nitrogen varied with season (quadratic, $P < .05$), with the months of December and February having the lowest, while June and August had the highest levels. The nitrogen decrease in lagoons during the warmer season can be explained by an increase in the activity of bacteria that convert the nitrogen into ammonia, which is volatilized.

Phosphorus and phosphate concentrations were influenced (quadratic, $P < .05$) by season, with the highest levels occurring during June and August, and the lowest during February and December. Also, the concentration of potassium, potash, and chloride increased (linear, $P < .05$) during the year. A quadratic effect ($P < .05$) was demonstrated for all other major (calcium,

Table 1. Effects of Production Phase on Mean Nutrient Concentration of Kansas Swine Lagoons[a]

Item	Sow	Nursery	Wean to Finish	Finish	Farrow to Finish	SEM	Overall Mean
Number of samples	50	44	41	56	45		236
Nitrogen, ppm							
Nitrate, NO_3^--N	< 1	< 1	< 1	< 1	< 1	0.33	< 1
Ammonium, NH_4^+-N	841^{fg}	$1,252^{fg}$	$1,506^{f}$	$1,469^{f}$	643^{g}	250	1,142
Organic N[b]	125^{h}	312^{fg}	346^{f}	351^{f}	166^{gh}	86	260
Total N	967^{g}	$1,563^{fg}$	$1,852^{f}$	$1,820^{f}$	810^{g}	420	1,402
Major nutrients, ppm							
Phosphorus, P	141^{fg}	223^{fg}	302^{f}	246^{fg}	106^{g}	80	204
Phosphate, P_2O_5[c]	320^{fg}	503^{fg}	686^{f}	559^{fg}	241^{g}	185	462
Potassium, K	856^{g}	$1,351^{fg}$	$1,750^{f}$	$1,786^{f}$	$1,125^{fg}$	432	1,374
Potash, K_2O[d]	$1,030^{g}$	$1,625^{fg}$	$2,106^{f}$	$2,150^{f}$	$1,354^{fg}$	517	1,653
Calcium, Ca	225^{gh}	463^{fg}	465^{fg}	500^{f}	198^{h}	120	370
Sodium, Na	284	282	437	439	281	90	345
Chloride, Cl	509^{h}	647^{fgh}	994^{fg}	$1,013^{f}$	sá1[fgh]	219	767
Magnesium, Mg	30^{h}	89^{fgh}	112^{f}	97^{fg}	43^{gh}	30	74
Sulfur, S	30^{g}	105^{f}	110^{f}	94^{f}	36^{g}	30	75
Copper, Cu	1.0^{g}	6.1^{f}	3.1^{fg}	3.7^{fg}	1.5^{g}	1.6	3.1
Zinc, Zn	3.1^{g}	40.7^{f}	20.2^{g}	16.2^{g}	4.0^{g}	9.7	16.8
Iron, Fe	14.8^{gh}	58.0^{f}	41.0^{fg}	35.4^{fgh}	10.7^{h}	13.9	32
Manganese, Mn	1.3^{g}	4.2^{f}	4.4^{f}	4.4^{f}	1.2^{g}	1.3	2.5
Other Constituents							
Carbonate, CO_3	< 1	< 1	< 1	< 1	< 1	0.1	< 1
Bicarbonate, HCO_3	$4,840^{g}$	$7,380^{fg}$	$8,817^{f}$	$9,199^{f}$	$4,645^{g}$	1,830	6,976
Solids, %	0.5^{g}	1.2^{fg}	1.3^{f}	1.3^{f}	0.6^{g}	0.3	1
pH	7.8	7.7	7.8	7.8	7.7	0.1	7.8
EC[e], mmho cm^{-1}	6.9^{gh}	9.0^{fgh}	9.5^{f}	9.1^{fg}	6.4^{h}	1.3	8.1

[a]A total of 236 samples representing 42 lagoons sampled from February through December 2000.
[b]Calculated (Organic N = Total N - NH_4^+-N - NO_3^--N).
[c]Calculated (P_2O_5 = P / .44).
[d]Calculated (K_2O = K / .83).
[e]Electrical Conductivity, mmho cm^{-1}.
[fgh]Means in same row with superscripts differ ($P < .05$).

sodium, magnesium, and sulfur) and minor (copper, zinc, iron, and manganese) nutrients. This response was indicated by an increase in nutrient concentration during warmer months followed by a decrease in the cooler months, except for sodium, which had the opposite response.

Hoop Barn Manure Concentrations. All hoop barns sampled in this study housed grow-to-finish pigs, therefore, no effects of production phase could be determined. Seasonal alterations in manure were analyzed, but only mean values are shown in Table 3. No seasonal differences ($P > .05$) for nitrogen characteristics, phosphorus, potassium, calcium, magnesium, and sulfur were detected. Sodium, chloride, copper and manganese were the only nutrients measured that were influenced by season.

Nutrient values for hoop barn manure that were determined in this study are the first published for Kansas. One striking observation from these results is the higher nutrient concentration associated with hoop barn manure compared to other published values of swine manure with bedding. However, the percentage solids for hoop barn manure is much higher compared to those values (57% vs.18%), which contributes to higher nutrient concentrations.

Summary

Lagoon analyses revealed that nitrogen concentrations were lower during the summer and fall compared to winter and early spring. Levels of nitrogen were highest in nursery, wean-to-finish, and finishing lagoons compared with sow and farrow-to-finish lagoons. Phosphorus levels for all lagoons increased from February until June, but then declined steadily throughout the remainder of the year. The concentration of phosphorus also was highest for wean-to-finish and finishing lagoons and the lowest for farrow-to-finish lagoons. No seasonal changes in nitrogen and phosphorus concentrations were observed in manure from hoop barns. Therefore, our results suggest that season and type of production phase affect the nutrient content of Kansas swine lagoons, and producers will benefit from obtaining individual analyses from their lagoons when developing nutrient management plans rather than relying on published reference values.

Table 2. Effects of Season on Nutrient Concentration of Kansas Swine Lagoons for 2000[a]

Item	February	April	June	August	Oct.	Dec.
Number of samples	42	42	41	42	40	29
Nitrogen, ppm						
Nitrate, NO_3^--N	< 1	< 1	< 1	< 1	< 1	< 1
Ammonium, NH_4^+-N[b]	1,348	1,303	1,315	953	894	1,041
Organic N[c]	223	275	321	286	255	201
Total N[b]	1,571	1,579	1,635	1,239	1,151	1,241
Major Nutrients, ppm						
Phosphorus, P[c]	152	199	287	240	212	131
Phosphate, P_2O_5[c]	344	453	651	546	482	297
Potassium, K[b]	1,286	1,284	1,353	1,343	1,604	1,370
Potash, K_2O[b]	1,549	1,547	1,624	1,617	1,933	1,649
Calcium, Ca[c]	309	411	390	440	413	258
Sodium, Na[c]	393	305	318	321	391	339
Chloride, Cl[b]	754	647	774	784	891	748
Magnesium, Mg[c]	3880	102	115	73	39	
Sulfur, S[c]	4685	95	99	77	47	
Copper, Cu[c]	1.3	3.2	5.1	4	2.8	2
Zinc, Zn[c]	8.2	16.8	23.1	26.6	18.5	8
Iron, Fe[c]	1830.4	40.9	55.5	34.3	12.9	
Manganese, Mn[c]	1.6	3.1	4.7	4.5	3.3	1.4
Other Constituents						
Carbonate, CO_3	< 1	< 1	< 1	< 1	< 1	< 1
Bicarbonate, HCO_3[bc]	7,039	7,013	8,288	6,814	6,460	6,244
Solids, %[g]	0.8	1	1.2	1.1	1.1	0.8
pH[b]	7.7	7.5	7.8	7.7	7.9	7.9
EC[bc], mmho cm^{-1}	4.8	8.5	8.9	8.7	10.1	8.2

[a]A total of 236 samples representing 42 lagoons sampled from February through December.

[b]Linear effect, ($P < .05$).

[c]Quadratic effect, ($P < .05$).

Table 3. Mean nutrient concentration of Kansas hoop barn manure

Item	Mean	SEM
Number of samples	35	
Nitrogen, ppm		
Nitrate, NO_3^--N	225	173
Ammonium, NH_4^+-N	2,003	518
Organic N[b]	6,431	896
Total N	8,678	1,177
Major Nutrients, ppm		
Phosphorus, P	4,364	645
Phosphate, P_2O_5	9,908	1,467
Potassium, K	8,867	1,184
Potash, K_2O[d]	10,673	1,425
Calcium, Ca	43,676	10,554
Sodium, Na	1,398	235
Chloride, Cl	2,429	376
Magnesium, Mg	3,210	325
Sulfur, S	1,564	230
Copper, Cu	140	54
Zinc, Zn	181	31
Iron, Fe	4,899	1,243
Manganese, Mn	236	39
Other Constituents		
Solids, %	57	6
pH	7.0	0.3
EC[e], mmho cm^{-1}	7.1	0.6

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Growing Pig, 10 a.m. to noon; *Sow Nutrition Management*, 1 p.m. to 3 p.m.
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