MINERAL LEVELS OF BROILER HOUSE LITTER AND FORAGES AND SOILS FERTILIZED WITH LITTER

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Story in Brief

Mineral levels were measured in samples of broiler feeds, broiler house litter, soils repeatedly fertilized with or without litter and forages grown on these soils. Soils with a history of poultry litter applications had higher levels of phosphorus than those untreated. Other minerals including sulfur, magnesium, calcium, iron, potassium, copper, zinc, sodium, aluminum, cadmium, lead, arsenic and selenium were observed. Manganese and copper levels tended to be higher in non fertilized soil samples. Forages from soils fertilized with poultry litter had higher levels of protein, phosphorus, copper, sodium and potassium. Copper and zinc levels were very high in poultry feed samples. Levels of all minerals in fresh broiler house litter exceeded beef cattle requirements even if litter was fed at only 20% of the diet. Arsenic and selenium levels approached maximum tolerable levels for beef cattle. Deep stacking increased mineral levels in litter. The greatest concern with using these litter samples in cattle feeds is the extremely high copper levels (3 to 9 times maximum tolerable levels and 46 to 134 times the requirement). If litter is to be recommended for sustained feeding to beef cattle, the commercial poultry industry needs to determine if these very high levels of copper and zinc are really required by poultry.

(Key Words: Poultry Litter, Minerals, Forages, Beef Cattle.)

Introduction

The commercial poultry industry has expanded greatly in Eastern Oklahoma during the past 10 years. Based on experience from neighboring states with large poultry industries, there is concern about the proper disposal of litter from concentrated numbers of broiler and laying houses. Typically, litter management has been accomplished by removal once or twice each year from the houses and spreading it for fertilizer on nearby pasture lands. Some

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litter has also been used directly by feeding to beef cattle. Litter may vary in nutrient content and contain high levels of some minerals, particularly copper. Concerns also arise about possible build up of mineral levels in soil fertilized repeatedly with litter and also in forages grown on these soils. The objective of this research was to measure levels of essential and also possibly toxic minerals in commercial broiler house litter, soils repeatedly fertilized with litter and in forages grown on these soils.

Materials and Methods

Samples were taken from 14 broiler/cattle operations along the Oklahoma-Arkansas state border and two samples from one operation in southwest Missouri. All samples were taken in June, 1992. Samples included poultry feeds, broiler litter, deep stacked broiler litter, and soil and forage samples from pastures receiving broiler litter fertilization and adjacent similar pastures receiving none.

Fresh broiler litter samples consisted of all the litter (bedding and manure) from a 6-inch wide trench to a depth of contact with the earthen pad, were taken from houses containing the last batch of birds prior to house cleaning or from empty houses before cleanout. Samples represent houses operated under several integrators with the number of batches of birds run in each house ranging from three to six. The trench, dug with a shovel, began at the mid-line of the house and proceeded laterally to the wall. Care was taken to avoid soil contamination of the litter. Samples were then frozen until shipment to the laboratory. Deep stacked broiler litter samples were taken with a shovel at various depths and locations from litter stacks aged from 12 weeks to one year. One sample represented a commercially available pellet made from composted litter.

Forage samples were collected by harvesting from at least 6 random sites measuring 1.5 X 3 ft across the pastures until enough grass was collected to provide >1 pound of dry matter for the laboratory. Samples were air-dried prior to shipment. Representative soil samples were taken to depths of six inches. These forage and soil samples were obtained from Bermuda or fescue pastures which had a history of fertilization with 2-4 tons of poultry litter per acre. These pastures were selected not only for their fertilization history but also for the purity of the grass stand and proximity of similar (grass and soil) pastures not fertilized with poultry litter, from which soil and forage samples were collected for comparison. Commercial fertilizers may have been applied to control pastures. Feed samples were taken from feed bins with permission and assistance from the cooperators. One sample was obtained from a commercially available poultry feed.

Samples were analyzed by a commercial laboratory. Comparisons included raw vs deep stacked litter samples, and fertilized vs non fertilized soils and forages. Detection limits for Cd, Mo, Pb, As and Se were .1, .12, 1.25, .15 and .15 ppm, respectively for soil samples and .5, 1.0, 5.0, .15 and .15 ppm respectively for forage samples.

Results and Discussion

Samples of soils with a history of poultry litter applications showed higher levels of phosphorus ($P<.01$) than those untreated with poultry litter (Table 1). This is to be expected since litter contains valuable levels of essential plant nutrients. The other soil nutrients including sulfur, potassium, magnesium, calcium, iron, zinc and molybdenum did not show a detectable build up from successive years of poultry litter applications. This is also consistent with expectations because litter contains only trace amounts of most of these nutrients. Copper and manganese were found in higher concentrations in non fertilized soils ($P<.10$). No trend toward soil build up of sodium, aluminum, cadmium, lead, arsenic and selenium was observed.

Forages from soils fertilized with poultry litter had higher levels of crude protein ($P<.01$), phosphorus ($P<.05$), sodium ($P<.05$) and potassium ($P<.01$) (Table 1) This is attributed to differences in applied levels of these nutrients between litter-treated and non fertilized samples from the same location. If levels of available N, P, and K equating those of poultry litter fertilization had been applied using commercial fertilizers, the resulting levels of these nutrients would be similarly increased. No potential problems with toxicity of any mineral in forages from litter-fertilized pastures were obvious.

Copper levels were slightly lower in the litter-fertilized soil ($P<.10$) and were greater in forage ($P<.001$) produced on that land. Given the high levels of copper in the poultry litter used as fertilizer, and increased forage production from fertilization, it is likely that added soil copper is assimilated by the forage. The increased copper levels from forages fertilized with litter may be desirable because forages grown in adjacent pastures appear to be borderline deficient in copper. The increased copper may, however, be offset by increased levels of molybdenum from litter-fertilized pastures. Molybdenum will bind copper decreasing its availability to cattle.

Though not found in comparative concentrations in commercial fertilizer, the sodium found in poultry litter resulted in an increased level of this element in fertilized forage. Soil samples appeared similar indicating that the majority of these applied minerals were mobilized by the plants.

Sampled feeds included starter, grower and withdrawal diets from producers feeding for different integrators (Table 2) The commercial starter-grower feed was similar in mineral content to feed from integrators except for copper, zinc, sodium and arsenic levels which were especially greater in integrator diets.

Table 1. Mineral analysis of soils and forages from adjacent pastures fertilized with or without broiler litter.

Soils	Fertilized		Non fertilized		Prob.[a]
	Mean	S.D	Mean	S.D.	
Protein, %	.886	.62	.605	.20	
Sulfur, %	.013	.008	.01	.00	
Phosphorus, %	.052	.011	.028	.004	P<.01
Potassium, %	.038	.014	.028	.013	
Magnesium, %	.038	.018	.04	.017	
Calcium, %	.235	.167	.155	.076	
Sodium, %	.004	.001	.003	.002	
Iron, ppm	7372	2337	9650	4957	
Aluminum, ppm	3169	834	3396	797	
Manganese, ppm	834	376	1302	469	P<.10
Copper, ppm	10.5	5.7	20.5	11.3	P<.10
Zinc, ppm	26	10	19.7	6	
Cadmium, ppm	not detected		not detected		
Molybdenum, ppm	.67	.26	.58	.2	
Lead, ppm	5.7	2.64	8.58	3.77	
Arsenic, ppm	8.47	5.45	7.91	3.75	
Selenium, ppm	.18	.17	not detected		
Forages					
Protein, %	17.75	2.77	12.54	1.92	P<.01
Sulfur, %	.31	.05	.27	.06	
Phosphorus, %	.47	.04	.34	.12	P<.05
Potassium, %	3.01	.17	2.26	.38	P<.01
Magnesium, %	.23	.02	.24	.06	
Calcium, %	.58	.17	.62	.25	
Sodium, %	.03	.01	.01	.01	P<.05
Iron, ppm	190	102	214	222	
Aluminum, ppm	45	37	57	65	
Manganese, ppm	128	69	223	109	
Copper, ppm	8.3	.82	5.5	1.22	P<.001
Zinc, ppm	34	8	36	7	
Cadmium, ppm	not detected		not detected		
Molybdenum, ppm	1.2	.62	.57	1.06	
Lead, ppm	N/D	0	.87	.66	
Arsenic, ppm	.08	0	.25	.38	
Selenium, ppm	not detected		not detected		

[a] Significance level.

Table 2 Mineral analysis of poultry feed.

Feeds	Starter	Grower	Withdrawal	Commercial
Macro minerals				
Protein, %	23.94	22.81	21.88	18.56
Sulfur, %	.30	.28	.29	.30
Phosphorus, %	.95	.85	.82	.97
Potassium, %	.95	.84	.75	.95
Magnesium, %	.18	.16	.19	.32
Calcium, %	1.16	.95	1.09	1.03
Sodium, %	.296	.219	.245	.178
Trace Minerals				
Iron, ppm	250	214	243	262
Aluminum, ppm	83	65	74	104
Manganese, ppm	268	252	157	155
Copper, ppm	242	146	298	19
Zinc, ppm	263	223	174	128
Cadmium, ppm	N/D[a]	N/D	N/D	N/D
Molybdenum, ppm1.13	.82	.63	.47	
Lead, ppm	N/D	1.85	N/D	2.27
Arsenic, ppm	.32	45.8	26.1	.21
Selenium, ppm	N/D	N/D	N/D	N/D

[a] N/D=not detected, below laboratory detection limits in all samples.

Fresh litter samples contained from 19 to over 31 percent crude protein (Table 3) These values are consistent with published levels of litter. Protein levels tended to be lower in deep stacked compared to fresh litter. This would be expected because some nitrogen will be volatilized from the heating that occurs in the stack. Mineral levels tended to be higher in deep stacked litter than in fresh litter. Undoubtedly some composting occurs within the stack which will reduce carbohydrate levels and increase mineral levels on a percentage basis.

Levels of many minerals in fresh and deep stacked broiler litter exceed beef cattle requirements if fed in excess of 20% of cattle diets. Potassium appeared to approach the maximum tolerable level. This is not a major concern if the potassium is from organic (plant) sources rather than from an inorganic source such as potassium chloride. Note that potassium levels in forage samples (Tables 1) often exceeded levels in litter.

Calcium, phosphorus and magnesium levels in litter also approached or exceeded maximum tolerable levels but were in proper ratios for beef cattle.

Table 3 Mean mineral analysis of broiler litter.

	Litter type				
	House Floor		Deep stacked		
	Mean	S.D.	Mean	S.D.	Prob.[a]
Macro minerals					
Protein, %	25.05	6.5	20.81	2.4	
Sulfur, %	.67	.09	.71	.08	
Phosphorus, %	2.09	.32	2.57	.38	P<.05
Potassium, %	2.72	.25	2.80	.35	
Magnesium, %	.66	.06	.87	.18	P<.05
Calcium, %	2.84	.32	3.72	.57	P<.01
Sodium, %	.77	.09	.83	.2	
Trace Minerals					
Iron, ppm	1144	249	2510	1644	
Aluminum, ppm	579	287	1288	626	P<.05
Manganese, ppm	671	266	939	221	
Copper, ppm	613	228	594	182	
Zinc, ppm	543	143	677	120	
Cadmium, ppm	.5	.21	.72	.15	P<.10
Molybdenum, ppm	3.77	.53	4.69	.36	P<.01
Lead, ppm	N/D[b]		1.68	2.41	
Arsenic, ppm	29.1	5.3	37.6	5.51	P<.05
Selenium, ppm	.82	.43	1.25	.18	P<.10

[a] Significance level
[b] N/D=not detected, below laboratory detection limits .

Litter would probably make up only 25 to 50% of the total diet of cattle and, therefore, levels of calcium, phosphorus and magnesium in the total diet would be acceptable in most situations. Sodium was present in amounts greater than required suggesting that poultry diets should be evaluated to determine if the salt level could be reduced. Levels of iron and aluminum are very high in litter samples. The solubility (availability) of these minerals from soil may be poor enough that they pose no real problems.

Arsenic and selenium are also present in levels approaching or exceeding maximum tolerable levels for beef cattle. The maximum allowable level of selenium in cattle diets is currently .3 ppm. Dilution of litter in cattle diets could minimize potential problems with arsenic and selenium. The greatest concern with using these litter samples in cattle feeds is the extremely high copper levels (3 to 9 times maximum tolerable levels and 46 to 134 times the requirement). Litter should obviously never be fed to sheep, a species very sensitive to copper. The molybdenum level is also quite high but not nearly high enough to bind the amount of copper present in these litter samples. Zinc levels are also very high, many times the requirement for beef cattle. If litter is to be recommended for sustained feeding to beef cattle, the commercial poultry industry needs to determine if these very high levels of copper and zinc are really required by poultry.