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

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SUMMARY

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 soil nutrients including sulfur, magnesium, calcium, iron, potassium, copper, zinc and molybdenum did not show a detectable buildup from successive years of poultry litter applications. There was no soil buildup of non-essential plant elements including sodium, aluminum, cadmium, lead, arsenic and selenium. Manganese and copper levels were higher in nonfertilized soil samples.

Forages from soils fertilized with poultry litter had higher levels of crude protein, phosphorus, potassium, sodium, and copper, consistent with forages grown on well-fertilized soils. Increased copper levels from forages fertilized with litter may be desirable because forages from adjacent pastures were borderline deficient in copper.

Copper and zinc levels were very high in feed samples from integrators. Levels of all minerals in fresh broiler house litter exceeded beef cattle requirements even if litter was fed at only 25% of the diet. Levels of iron, aluminum and manganese were very high in litter samples. Deep stacked litter

samples showed higher levels of phosphorus, magnesium, calcium, aluminum, cadmium, molybdenum, arsenic, and selenium than raw litter samples.

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). Zinc levels are also very high in litter, 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 feed levels of copper and zinc are really required by poultry.

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 manure and 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 value on nearby pasture lands. Some litter has also been used directly by feeding to beef cattle.

Preliminary analysis has shown that broiler house litter may be highly variable in nutrient content and contain high levels of some minerals, particularly copper (Battachara et al., 1975; Ruffin et al., 1981). 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 as may be fed to cattle, soils repeatedly fertilized with litter and in forages grown on these soils.

MATERIALS AND METHODS

Various 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 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. Samples consisted of all the litter (bedding and manure) from a 6-inch wide trench to a depth of contact with the earthen pad. 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. This procedure served to obtain a representative sample of the entire house including feed and water lines as well as loafing areas. The 40-60 gal. of litter collected was thoroughly mixed on a tarpaulin in the house with a 1.5 pound sample taken from the total. This procedure was repeated in brooder and grower ends of each house with the smaller samples mixed to obtain the overall house sample. These samples were then frozen until shipment to the laboratory. The litter collected represents that which is commonly applied to land in the Oklahoma-Arkansas area.

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. The larger sample was subsampled after mixing to obtain a 1-1.5 pound amount. One sample represented a commercially available pellet made from composted litter. Samples were frozen until shipment.

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 poultry litter. Litter had been applied in amounts of 2-4 tons/acre at least annually. 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&L Agricultural Laboratories, Inc., Omaha, Nebraska (an independent agricultural laboratory). Analysis included: total nitrogen (N), sulphur (S), phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), sodium (Na), iron (Fe), aluminum (Al), manganese (Mn), copper (Cu), zinc (Zn), cadmium (Cd), molybdenum (Mo), lead (Pb), arsenic (As) and selenium (Se). Nitrogen content was determined using the Kjeidahl method. All other elements were analyzed using atomic absorption and emission spectroscopy. Data were analyzed using General Linear Models procedure. Comparisons included raw vs deep stacked litter samples, and fertilized vs nonfertilized soils and forages. For statistical analysis, numerical levels of elements found to be less than laboratory detection limit were defined as the average of zero and the detection limit. 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

Soils. Samples of soils with a history of poultry litter applications showed a higher level 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. Phosphorus is immobile in the soil, therefore, a soil buildup of this nutrient is an agronomically preferred practice. Most all native soils in eastern Oklahoma are deficient in this nutrient for optimum forage/crop production. Hence, a small buildup simply increases the availability of phosphorus to plants for future production.

The other soil nutrients including sulfur, potassium, magnesium, calcium, iron, zinc and molybdenum did not show a detectable buildup 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 nonfertilized soils (P<.10).

Non-essential plant elements including sodium, aluminum, cadmium, lead, arsenic and selenium occur in trace amounts in litter. No trend toward soil buildup was implied from the data.

Forages. Forages from soils fertilized with poultry litter had higher levels of crude protein (P<.01), phosphorus (P<.05), sodium (P<.05) potassium (P<.01) and copper (P<.001) (Table 2). This is attributed to differences in applied levels of these nutrients between litter-treated and nonfertilized 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 (Eichhorn et al., 1984).

The protein, phosphorus, calcium, potassium and magnesium content of forages from pastures fertilized with litter were consistent with forages from highly fertile soils.

Because energy content is highly correlated with protein content, these forages would be expected to provide excellent cattle performance. 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 on 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.

Poultry feeds. Sampled feeds included starter, grower and withdrawal diets from producers feeding for different integrators. Broiler feeds contained high levels of protein and minerals compared to cattle rations (Tables 3 and 5). 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.

Sodium was present in integrated company broiler diets at levels approaching 2x the NRC requirement. The high sodium levels found in litter and fertilized forages may affect cattle diet formulations and could potentially increase salinity of the soils, although no sodium accumulations were noted in this study.

Poultry diets should be evaluated to determine if the salt level could be reduced. The cattle feedlot industry has reduced salt levels to .3% and lower in rations in an effort to reduce salinization of soils fertilized with manure. Cattle performance has not been affected.

Broiler house litter. Accepted feeding levels along with maximum tolerable levels and toxic levels of minerals for beef cattle (NRC 1984) are shown in Table 5. Fresh litter samples contained from 19 to over 31 percent crude protein (N x 6.25) (Table 4). These values are consistent with published nitrogen levels of litter from other sources (Battachara et al., 1975; Ruffin et al., 1981). Although not statistically significant, nitrogen levels tend 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 25% of cattle diets. Sulfur levels are high but expected in feeds containing large percentages of protein. Phosphorus levels exceed the NRS recommended range for beef cattle. This is not a major concern if litter is diluted in the diet and the potassium is from organic (plant) sources rather than from an inorganic source such as potassium chloride. Note that potassium levels in forage samples (Table 2) exceed levels in sampled litter.

Calcium and phosphorus levels in litter exceeded maximum tolerable levels but were in proper ratios for beef cattle. Litter would probably make up only 25 to 50% of the total diet of cattle and, therefore, levels of calcium and phosphorus in the total diet would be acceptable in most situations.

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.

Table 1. **Mean mineral analysis of soils from adjacent pastures fertilized with or without broiler litter.**

Macrominerals	Fertilized		Nonfertilized		Prob.[a]
	Mean	S.D.	Mean	S.D.	
Crude Protein (N), %	.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	
Trace Minerals					
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	N/D[b]		N/D		
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	N/D		

[a] Probability that the difference between means could occur by chance.
[b] N/D=Not detected, below laboratory detection limits in all samples.

Table 2. **Mean mineral analysis of forages from adjacent pastures fertilized with or without broiler litter.**

Macrominerals	Fertilized Mean	Fertilized S.D.	Nonfertilized Mean	Nonfertilized S.D.	Prob.[a]
Crude Protein (N), %	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
Trace Minerals					
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	N/D[b]		N/D		
Molybdenum, ppm	1.2	.62	.57	1.06	
Lead, ppm	N/D	0	.87	.66	
Arsenic, ppm	.08	0	.25	.38	
Selenium, ppm	N/D		N/D		

[a] Probability that the difference between means could occur by chance.
[b] N/D=not detected, below laboratory detection limits in all samples.

Table 3. Mineral analysis of poultry feed.

Feeds	Starter	Grower	Withdrawal	Commercial
Macrominerals				
Crude protein, %	23.94	22.31	21.38	18.56
Sulfur, %	.3	.28	.29	.3
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, ppm	1.13	.82	.63	.47
Lead, ppm	N/D	1.85	N/D	2.27
Arsenic, ppm	.32	45.3	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.

Table 4. Mean mineral analysis of broiler litter.

Litter type	House Floor		Deep stacked		Prob.[a]
Macrominerals	**Mean**	**S.D.**	**Mean**	**S.D.**	
Crude protein (N), %	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	2.8	.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	237	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 probability that the difference between means could occur by chance.
b N/D=not detected, below laboratory detection limits in all samples.

Table 5. **Mineral requirements and maximum** tolerable levels for beef cattle[a].

Mineral	Requirement: Suggested Value	Requirement: Range[b]	Maximum Tolerable Level[c]
Calcium, %	---	.5 to .7	2
Cobalt, ppm	0.10	0.07 to 0.11	5
Copper, ppm	8	4 to 10	115
Iodine, ppm	0.5	0.20 to 2.0	50
Iron, ppm	50	50 to 100	1000
Magnesium, %	0.10	0.05 to 0.25	0.40
Manganese, ppm	40	20 to 50	1000
Molybdenum, ppm	---	---	6
Phosphorus, %	---	.25 to .4	1
Potassium, %	0.65	0.5 to 0.7	3
Selenium, ppm	0.20	0.05 to 0.30	2
Sodium, %	0.08	0.06 to 0.10	10[d]
Chlorine, %	---	---	---
Sulfur, %	0.10	0.08 to 0.15	0.40
Zinc, ppm	40	20 to 40	500

Nutrient Req. of Beef Cattle, 6th ed. (1984).a
[b]The listing of a range in which requirements are likely to be met recognizes that requirements for most minerals are affected by a variety of dietary and animal (body weight, sex, rate of gain) factors. Thus, it may be better to evaluate rations based on a range of mineral requirements and for content of interfering substances than to meet a specific dietary value.
[c]From NRC (1980).
[d]10% sodium chloride.

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Mineral levels of broiler house litter and forages and soil fertilized with litter. S.C. Smith, J.G. Britton, J.D. Enis, K.C. Barnes and K.S. Lusby, Oklahoma State University, Stillwater.

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Beef cattle, poultry litter, animal waste