

ABSTRACT

Land application of broiler litter can cause changes in surface runoff quality. While elevated concentrations of N and P have been observed in surface runoff from broiler litter amended fields, impacts of other nutrients in broiler litter such as Ca, K, Mg, Mn, Cu and Zn have not been identified. A study was conducted on a 4% slope during 1991-1993 at Belle Mina, Alabama on a Decatur silty clay (clayey, kaolinitic, thermic Rhodic Paleudults) to determine the effects of broiler litter (BL) on seasonal transport losses of nutrients and metals in surface water. A corn (*Zea mays* L.) - winter rye (*Secale cereale* L.) cropping system was fertilized with either: 1) 9 Mg BL ha<sup>-1</sup> (BL9), 2) 18 Mg BL ha<sup>-1</sup> (BL18), or 3) commercial fertilizer at the recommended rate (F). Sediment nutrient concentrations of K, Mg and Mn, and seasonal transport losses of sediment Mn were highest under F during the second corn season. Dissolved nutrient concentrations of Ca, K and Mg were highest under BL18 during the second corn season. It appears BL impacts water quality through dissolved nutrient losses, while F poses more of a threat via sediment nutrient losses.

INTRODUCTION

Water quality becomes a concern when using broiler litter as a nutrient source. Broiler litter application has increased N and P levels in surface runoff and is well documented (Westerman et. al., 1983; McLeod and Hegg, 1984; Edwards and Daniel, 1993). Long-term and relatively short term applications of broiler litter results in high concentrations of K, Ca, Mg, Mn, Cu and Zn in the soil surface (Liebhart, 1976; Morrison, 1969; Kingery et.al, 1993, 1994) and may contribute to nutrient losses via nutrient losses via runoff. Recent studies have addressed metal losses in runoff from poultry litter applications (Edwards et. al., 1997; Moore et. al., 1998), but were conducted on small plots and may represent worse-case scenario. The objective of this study was to determine loss of nutrients and heavy metals via surface runoff on field plots amended with broiler litter.

METHODS

- Location: Tennessee Valley Substation, Belle Mina, Alabama
- 4% slope
- Three treatments:
  - Broiler Litter at 9 Mg ha<sup>-1</sup> (BL9)
  - Broiler Litter at 18 Mg ha<sup>-1</sup> (BL18)
  - Commercial Fertilizer at the recommended rate (F)
- Plot size = 0.1 ha
- Samples collected after each runoff producing storm.
- Samples frozen until analyses
- Samples filtered through a 0.45µm filter
- Sediment on filter retained for elemental analyses.
- Dissolved and sediment nutrients analyzed for Ca, K, Mg, Mn, Cu and Zn (ICAP 9000, Thermo Jarrell Ash, Franklin, MA).

TABLE 1. Selected characteristics of broiler litter applied on a dry weight basis at the site.

Component	Year	
	1991	1992
Moisture (g kg <sup>-1</sup> )	249	57
Total N (g kg <sup>-1</sup> )	25.8	43.6
Total C (g kg <sup>-1</sup> )	250	337
Ash (g kg <sup>-1</sup> )	379	201
NH <sub>4</sub> -N (mg kg <sup>-1</sup> )	6652	5898
NO <sub>3</sub> -N (mg kg <sup>-1</sup> )	12	363
pH (1:4)	8.5	7.0
EC (S m <sup>-1</sup> )	0.55	0.72
S (g kg <sup>-1</sup> )	3.0	5.0
P (g kg <sup>-1</sup> )	14.8	34.0
K (g kg <sup>-1</sup> )	19.5	48.0
Ca (g kg <sup>-1</sup> )	19.5	45.0
Mg (g kg <sup>-1</sup> )	4.7	10.0
Fe (mg kg <sup>-1</sup> )	648	990
Cu (mg kg <sup>-1</sup> )	313	778
Zn (mg kg <sup>-1</sup> )	327	910
Mn (mg kg <sup>-1</sup> )	246	958



Runoff volume was monitored by 0.305 meter H-flumes equipped with runoff hydrograph recorders. A model N-1 Coshoc-ton-Type runoff sampler and runoff storage tank were used for runoff sample collection.

TABLE 3. Sediment flow-weighted concentrations in runoff water as affected by soil amendment applications.

Parameter	Soil Amendment†	Crop Season-----			
		Corn 1‡	Rye 1§	Corn 2¶	Rye 2#
-----mg L <sup>-1</sup> -----					
Sediment Ca	F	0.66	0.24	0.77	0.44
	BL9	0.66	0.29	0.52	0.57
	BL18	1.32	0.24	0.89	0.64
	LSD 0.10	NS††	NS	0.05	NS
Sediment K	F	0.48	0.25	1.25	0.83
	BL9	0.41	0.31	0.84	1.13
	BL18	0.45	0.29	0.68	1.12
	LSD 0.10	NS	NS	0.34	NS
Sediment Mg	F	0.47	0.53	0.54	††BDL
	BL9	0.44	0.50	0.39	BDL
	BL18	0.80	0.55	0.30	BDL
	LSD0.10	NS	NS	0.04	NS
Sediment Mn	F	0.86	0.20	0.73	BDL
	BL9	0.50	0.20	0.36	BDL
	BL18	1.50	0.23	0.29	BDL
	LSD 0.10	NS	NS	0.19	NS
Sediment Cu	F	0.01	BDL	0.01	BDL
	BL9	0.01	BDL	0.02	0.01
	BL18	0.01	BDL	0.01	0.01
	LSD 0.10	NS	NS	NS	NS
Sediment Zn	F	1.34	0.23	1.16	BDL
	BL9	1.41	0.27	0.84	BDL
	BL18	2.12	0.21	0.81	BDL
	LSD0.10	NS	NS	NS	NS

†F=commercial fertilizer, BL9=9 Mg broiler litter ha-1, BL18=18 Mg broiler litter ha-1  
 ‡Corn grown March to September 1991  
 §Rye grown September 1991 to March 1992  
 ¶Corn grown March to September 1992  
 #Rye grown September 1992 to March 1993  
 ††Not Significant at the 0.10 level of probability  
 ††BDL (Below Detection Limits)

TABLE 2. Seasonal transport losses of sediment and flow-weighted concentrations of sediment from surface water as affected by soil amendment applications.

Parameter	Soil Amendment †	Crop Season-----			
		Corn 1‡	Rye 1§	Corn 2¶	Rye 2 #
-----kg ha <sup>-1</sup> -----					
Sediment	F	839	76.5	325.1	90.3
	BL9	690	85.8	111.2	82.1
	BL18	2209	105.7	86.8	42.2
	LSD0.10	NS††	NS	NS	NS
-----g L <sup>-1</sup> -----					
Sediment	F	0.62	0.08	0.35	0.16
	BL9	0.49	0.13	0.18	0.19
	BL18	1.35	0.10	0.13	0.16
	LSD0.10	NS	NS	0.13	NS

†F=commercial fertilizer, BL9=9 Mg broiler litter ha-1, BL18=18 Mg broiler litter ha-1  
 ‡Corn grown March to September 1991  
 §Rye grown September 1991 to March 1992  
 ¶Corn grown March to September 1992  
 #Rye grown September 1992 to March 1993  
 ††Not Significant at the 0.10 level of probability

TABLE 4. Dissolved nutrient flow-weighted concentrations in runoff water as affected by soil amendment applications.

Parameter	Soil Amendment†	Crop Season-----			
		Corn 1‡	Rye 1§	Corn 2¶	Rye 2#
-----mg L <sup>-1</sup> -----					
Dissolved Ca	F	5.84	1.77	5.09	2.56
	BL9	5.80	1.65	6.10	5.13
	BL18	8.44	1.80	10.95	4.64
	LSD 0.10	NS††	NS	3.97	NS
Dissolved K	F	4.76	3.55	5.25	4.42
	BL9	6.05	3.45	7.97	6.75
	BL18	13.99	3.49	16.06	7.52
	LSD 0.10	NS	NS	3.31	NS
Dissolved Mg	F	0.72	1.43	0.78	††BDL
	BL9	0.76	4.35	1.10	BDL
	BL18	1.56	1.79	2.71	BDL
	LSD0.10	NS	NS	0.56	NS
Dissolved Mn	F	0.09	0.01	0.18	BDL
	BL9	0.10	0.02	0.03	BDL
	BL18	0.29	0.02	0.16	BDL
	LSD 0.10	0.07	NS	NS	NS
Dissolved Cu	F	0.03	BDL	0.04	0.16
	BL9	0.05	BDL	0.01	0.19
	BL18	0.10	0.01	0.02	0.13
	LSD 0.10	NS	NS	NS	NS
Dissolved Zn	F	0.61	0.25	0.71	BDL
	BL9	0.48	0.29	1.04	BDL
	BL18	0.36	0.32	0.72	BDL
	LSD0.10	0.15	NS	NS	NS

†F=commercial fertilizer, BL9=9 Mg broiler litter ha-1, BL18=18 Mg broiler litter ha-1  
 ‡Corn grown March to September 1991  
 §Rye grown September 1991 to March 1992  
 ¶Corn grown March to September 1992  
 #Rye grown September 1992 to March 1993  
 ††Not Significant at the 0.10 level of probability  
 ††BDL (Below Detection Limits)

CONCLUSIONS

The results of this study indicate differences due to fertilizer applications occurred most often during corn growing seasons. This is attributed to the period of limited or no soil cover after fertilizer application while corn is establishing itself. Litter treatments decreased sediment flow-weighted concentrations during the second corn growing season. Seasonal transport losses from all constituents decreased during rye growing seasons (data not shown). Excluding Ca, flow-weighted concentrations of all nutrients from all treatments provided adequate levels to support algae growth. It appears, however, that commercial fertilizer impacts water quality through sediment losses, while BL18 poses more of a threat through dissolved nutrients.

REFERENCES

Edwards, D.R., and P.A. Moore Jr., T.C. Daniel, P. Srivastava, and D.J. Nichols. 1997. Vegetative filter strip removal of metals in runoff from poultry litter-amended fescuegrass plots. *Trans. ASAE* 40(1):121-127.

Edwards, D.R., and T.C. Daniel. 1993. Effects of poultry litter application rate and rainfall intensity on quality of runoff from fescuegrass plots. *J. Environ. Qual.* 22:361-365.

Kingery, W.L., C.W. Wood, D.P. Delaney, J.C. Williams, and G.L. Mullins. 1994. Impact of long-term land application of broiler litter on environmentally related soil properties. *J. Environ. Qual.* 23:139-147.

Kingery, W.L., C.W. Wood, D.P. Delaney, J.C. Williams, and E. van Santen. 1993. Implications of long-term land application of poultry litter on tall fescue pastures. *J. Prod. Agric.* 6:390-395.

Liebhart, W.C. 1976. The arsenic content of comm grain grown on a coastal plain soil amended with poultry manure. *Comm. In Soil Sci. and Plant Anal.* 7:169-174.

McLeod, R.V., and R.O. Hegg. 1984. Pasture runoff water quality from application of inorganic and organic nitrogen sources. *J. Environ. Qual.* 12:122-126.

Moore, P.A. Jr., T.C. Daniel, J.T. Gilmour, B.R. Shreve, D.R. Edwards, and B.H. Wood. 1998. Decreasing metal runoff from poultry litter with aluminum sulfate. *J. Environ. Qual.* 27:92-99.

Morrison, J.L. 1969. Distribution of arsenic from poultry litter in broiler chickens, soils and crops. *J. Agric. Food Chem.* 17:1288-1290.

Westerman, P.W., T.L. Donnelly, and M.R. Overcash. 1983. Erosion of soil and poultry manure - a laboratory study. *Trans. ASAE* 26:1070-1078, 1084.