Water Quality Effects based on Soil Solution Nitrate-Nitrogen after Poultry Litter and Diammonium Phosphate plus Urea Applications in a Slash Pine Plantation in Brantley County Georgia

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INTRODUCTION
Poultry litter is commonly used as a fertilizer for pastures, hay fields, and cropland in Georgia. The repeated application of litter has led to elevated nutrient and bacteria levels in area streams. Application of litter to forestland is a promising alternative as there are over 24 million acres of forestland in Georgia. Many forest soils are low in available nitrogen (N) and phosphorus (P), and to a lesser extent, potassium (K). Southern pine tree and stand growth response to poultry litter applications can be significant and produce positive financial returns.

A study funded by the Georgia Environmental Protection Division (GA-EPD) was initiated to investigate the effects of poultry litter application to forestland on water quality. The focus of this paper was to quantify nitrate-N in soil solution by fertilizer treatment over a 3½ year study period.

METHODOLOGY
This study was initiated in 2001 to investigate water quality effects of Annual (poultry) litter (6950 lb/ac on 30 January 2002; 7180 lb/ac on 18 February 2003; and 7540 lb/ac on 24 February 2004) with an overall mean total-N of 1.80 percent on an “as sampled” basis; One-time litter (25540 lb/ac on 30 January 2002 with a mean 1.08 percent total-N on an as sampled basis; and DAP + urea, diammonium phosphate ((NH₄)₂HPO₄; 213 lb/ac P₂O₅ + 77 lb/ac N) + urea (CO(NH₂)₂; 123 lb/ac N) application in a 1994 planted slash pine (Pinus elliottii) stand in Brantley Country, Georgia.

The soil series of the study site was verified by a Natural Resource Conversation Service (NRCS) as primarily Hurricane (somewhat poorly drained, sandy, siliceous, thermic Oxyaquic Alorthods), and to a lesser extent, Chipley (somewhat poorly drained, sandy, thermic Aquic Quartzipsammets). Pre-treatment topsoil pH (0-6 inch) ranged from 5.4 to 6.0 in the Annual and One-time litter plots, 5.3 to 5.6 in the Control plots, and 5.2 to 5.5 in the DAP + urea plots.

The study area design was randomized complete block with three replications per treatment. Gross treatment plot size was 0.25 acres with 40 feet of untreated buffer between each plot. Porous cup suction lysimeters (two per plot) were installed to a depth of 3.3 feet in each plot (24 suction lysimeters in total). Groundwater wells were installed to the saturated water zone up-gradient of the study area, one plot for each treatment, and down-gradient of the study area in a line transect for a total of 6 wells to an average well depth of 18 feet. Background soil solution samples were taken prior to treatments (29 January 2002). Post-application soil solution and groundwater samples were collected every 3 months from March 2002 through July 2005.
A rainfall data recorder was installed on-site. However, electrical, rodent, and litterfall problems resulted in unreliable rainfall data collection. Therefore, rainfall data from a weather station located approximately 12 miles east of the site (Figure 1) were used during the study period to discern any rainfall pattern to nitrate-N concentration correlations.

**RESULTS**

The characteristics of the layer litter applied to individual plots during the study period were variable with percent solids ranging from 20 to 40 percent, total-N ranging from 1.02 to 3.46 percent, ammonium-N ranging from 0.06 to 1.2 percent, and nitrate-N ranging from 0.010 to 0.032 mg/l. These variable characteristics created a non-uniform distribution of the litter in the One-time and Annual litter plots. The lbs/ac application level differences ranged from 15 to 250 percent of the mean within individual plots.

The United States Environmental Protection Agency (EPA) drinking water standard for nitrate-N of 10 mg/l was used as a “threshold” value for both the suction lysimeters and well soil solution samples in this study. Soil solution nitrate-N means from the Annual litter applications were above the EPA drinking water threshold during all quarterly collection periods starting 12 months after the first application (January 2003), and remained above the threshold through July 2004, and then dropped to below 10 mg/l 33 months after the first application and 9 months after the third and final application in October 2004. Soil solution nitrate-N from the One-time litter application had one sample above the threshold at 15 mg/l 12 months after application (January 2003), which then declined to < 3 mg/l during the next collection period (April 2003). Soil solution nitrate-N levels from the DAP + urea application were above the threshold after application, 32 and 78 mg/l, 9 months (October 2002) and 12 months (January 2003), respectively. Then, 15 months after application, these numbers fell below the threshold. Study period mean lysimeter soil solution nitrate-N levels were 1.1 mg/l for the Control, 8.0 mg/l for the DAP + urea, 2.5 mg/l for the One-time litter, and 18.5 mg/l for the Annual litter.

Two well soil solution nitrate-N values were above 10 mg/l. The Control plot well had a soil solution nitrate-N value of 42 mg/l on the July 2003 sampling date. This was likely due to the landowner spreading the leftover litter that was piled adjacent to the Control plot in March 2002 and the continuation of the annual fertilizer regime on this adjacent field. None of the lysimeters in the same plot had soil solution values greater than 4.2 mg/l during the study period. The Annual litter well maximum soil solution nitrate-N value was 16 mg/l on the July 2004 sampling date, 6 months after the third and final annual application. The Up-gradient, DAP + urea, One-time litter, and Down-gradient wells did not produce soil solution nitrate-N values above 10 mg/l during the study period. Study period mean soil solution nitrate-N levels were 0.44 mg/l for the Up-gradient well, 4.7 mg/l for the Control, 0.08 mg/l for the One-time litter application, 0.17 mg/l for the DAP + urea, 3.2 mg/l for the Annual litter, and 1.1 mg/l for the Down-gradient well.

**SUMMARY AND DISCUSSION**

In this study, the One-time litter application of 25540 lb/ac (226 lb/ac NH₄-N and 55 lb/ac organic-N) had the least adverse effect on soil nitrate-N solution levels. All fertilization treatments had no major adverse effect on Down-gradient groundwater quality based on nitrate-N concentrations over the study period.

No correlations were detected between rainfall and soil solution peak nitrate-N patterns using monthly rainfall data from the nearest weather station. Nitrate-N concentrations were above 10 mg/l in the one-time DAP + urea application lysimeters in October 2002 after a 4.1 inch rainfall month (44 inches for January through October 2002) and in January 2003 after a 0.20 inch rainfall month (53 inches rainfall
January 2002 through January 2003). Lysimeter nitrate-N concentrations were above 10 mg/l in the One-time litter application in January 2003 after a 0.50 cm rainfall month (53 inches rainfall January 2002 through January 2003). Lysimeter nitrate-N concentrations were much above 10 mg/l in the Annual litter in April 2003 after a 3.7 inch rainfall month (58 inches for May 2002 through April 2003), July 2003 after a 12.8 cm rainfall month (59 inches for August 2002 through July 2003), and in April 2004 after a 5 inches rainfall month (49 inches for May 2003 through April 2004).

The DAP + urea and One-time litter application maximum nitrate-N concentration lysimeter values occurred 12 months after application, declining to values much below the 10 mg/l threshold starting 15 months after application. The Annual litter application had the most adverse water quality effect (based on nitrate-N concentrations in the suction lysimeters) of the three fertilization treatments used in this study. The Annual litter nitrate-N concentration increased at a slightly slower rate than the DAP + urea and One-time litter application, having a first major peak (60 mg/l) 18 months after the first application (5 months after the second application), and a second and final major peak (80 mg/l) 26 months after the initial application (14 months after the second application and 2 months after the third application). The Annual litter lysimeters nitrate-N concentration fell below the 10 mg/l threshold in October 2004, 33 months after the initial application (20 months after the second application and 8 months after the third and final application.

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