FINAL REPORT

Institute of Soil and Environmental Quality and Avian Biosciences Center Graduate Fellowship Program in the Environmental Compatibility of Poultry Production

Award Recipient Shreeram Inamdar

Department Bioresources Engineering

Date of Award 2006-2007

Title *Transport and Fate of Hormones and Trace Metals From Land-Applied Poultry and Dairy Waste*

Graduate Student on Fellowship Award: Sudarshan Dutta, Plant & Soils Sciences.

Date student started on Fellowship (joined graduate school at UD): September 2007.

Expected termination date of Fellowship: August, 2010 (3 year award).

Summary of Findings:

Summer 2007 experimental study:

- Experimental plot (5m x 12 m) studies were conducted in Middletown, DE (St. Andrews School Agricultural Land) to compare the exports of trace metal and nutrients in surface runoff from plots receiving pelletized poultry litter (PPL) and urea. Runoff from twelve natural storm events were sampled and analyzed.

- Experimental setup and data collection was performed by undergraduate students Nathan Kiracofe (on DWRC Internship) and David Gunzlyu. Data was analyzed in detail by Nathan Kiracofe and Sudarshan Dutta (ABC-ISEQ fellowship recipient) in the fall of 2007.

- Mass exports of ammonium and aluminum were greater in surface runoff from PPL-treated versus urea-treated plots. Thus, PPL may have a potential to increase the exports of nutrients in runoff. However, it should be emphasized that our PPL application rate (252 kg N/ha) was at the high end of N rates used for corn in Delaware. Management strategies such as incorporation of PPL into the soil via localized tillage should be explored to reduce the exports of nutrients and metals in surface runoff.

- Exports and concentrations of Cu and Zn from all plots were very low. Thus, this suggests that PPL may be a safe N source for corn with respect to trace metals.

<u>Preliminary results from 2008 experimental study</u>:

- Experimental plot studies were again conducted April-August, 2008. Mass exports and concentrations of hormones, trace metals, and nutrients were compared for plots receiving urea, PPL, control (no treatment), and raw poultry litter (2 different rates). The plots were in conventional (CT) and no tillage (NT). Data from a total of 12 storm events was collected.

- Hormone concentrations determined using ELISA kits were much greater than the values from LC/MS. This indicates that interferences associated with dissolved humics can considerably overestimate the hormone concentrations from ELISA. Estrone and Estradiol concentrations from no-till plots were higher than those from conventional tillage suggesting that no-till practices may increase the hormone exports in surface runoff. Our hormone concentrations (determined by LC/MS) were less than the concentration of 40 ng/L found to cause endocrine disruption in aquatic species (Yonkos, 2005). However, our values still exceeded the predicted no-effects concentration (PNEC) of 1ng/L established by Young et al. (2004). (See Figure 1 in appendix)

- Initial results suggest that highest concentrations of ammonium and nitrate in surface runoff were associated with PPL applications under conventional tillage (see Figure 2 in appendix). These observations are similar in trend to the observations from 2007. Concentrations of ammonium and nitrate from 2008 were higher because of very large concentrations associated with two large events. These data are based on 5 of the 12 events sampled – other samples are still being analyzed by the laboratory.

- Concentrations of Cu and Zn were fairly low in surface runoff across all treatments. These concentrations are much lower that environmental water quality protection standards, and thus indicate that PPL applications should not be of concern with respect to these metals. USEPA drinking water standard (mg/L) for Cu and Zn are 1.3 and 7.4, respectively. The USEPA freshwater chronic criterion (mg/L) for Cu and Zn is 7 and 97, respectively.

<u>Publications resulting from research</u>

- Dutta, S., S. Inamdar, J.T. Sims, and A. Collins. Nutrient and trace metal exports in surface runoff from experimental plots receiving pelletized poultry litter. In Preparation (first draft completed).
- An additional publication on hormones is being developed.

Presentations resulting from research (attached)

- Dutta*, S., S. Inamdar, J.T. Sims, A. Collins, and N Kiracofe**. 2008. Nutrient and trace metal export in surface runoff from plots receiving pelletized broiler litter. 2008 Joint Annual Meeting, October 5-9, Houston, TX.

- Kiracofe**, N., S. Dutta*, and S. Inamdar. 2008. Comparison of pelletized poultry litter and urea for surface water quality. Delaware Water Resources Center (DWRC) Annual Poster session, May 2, 2008.

* graduate student; ** undergraduate student.

Additional grant support received as a result of ABC grant

Grants received –

- 2007-2008: CANR Seed Grant Program. Amount = $10,000. PI = Inamdar, S. Transport of hormones from agricultural fields receiving manure and poultry waste: What are the controlling factors and mechanisms?

Proposals submitted (in review) -

- 2008 UDRF Strategic Grants RFP. Amount requested = $45,000. PIs = Inamdar, S. and J. T. Sims. Sex Hormones and Arsenic: Emerging Contaminants in Delaware's Streams.

New collaborations developed because of ABC grant

We have developed a new and very fruitful collaboration with Dr. Diana Aga from the Chemistry Department at the University of Buffalo at Buffalo, NY. Dr. Aga is an environmental chemist with expertise in analytical procedures for determining emerging contaminants such as hormones and pharmaceuticals.

We plan to use this new partnership to explore for additional funding opportunities (USDA, NSF, EPA) associated with hormones.

New educational opportunities associated with this grant

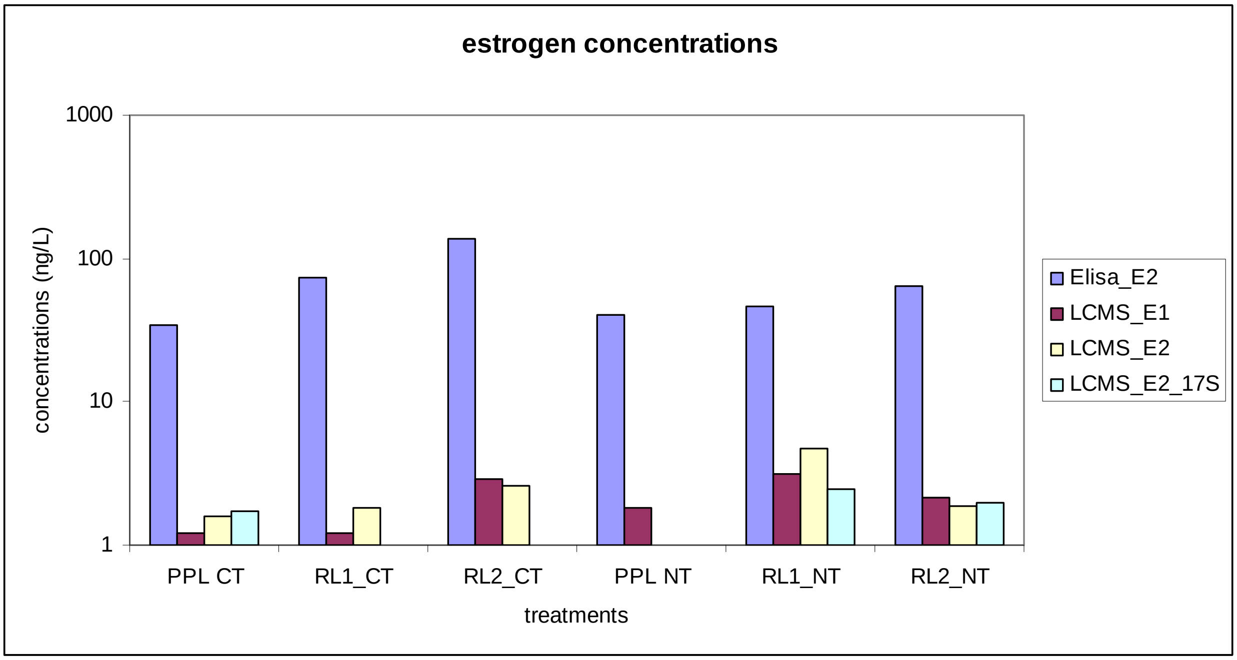
Because of this new research, I introduced a new section on environmental pollution from hormones in my BREG 621: Nonpoint Source Pollution course (Fall 2007). I invited Dr. Lance Yonkos (see Yonkos, 2005), to present a guest lecture on hormones. Dr. Yonkos is an expert on hormones and is located at the Wye Research Center of the University of Maryland. His presentation was very informative and was thoroughly enjoyed by the students.

<u>References</u>:

Yonkos, L. T. 2005. Poultry litter induced endocrine disruption: Laboratory and field investigations. PhD dissertation, University of Maryland Center for Environmental Science. Baltimore, MD.

Young, W. F.; Whitehouse, P.; Johnson, I.; Sorokin, N. 2004. Proposed predicted-no-effect-concentrations (PNECs) for natural and synthetic steroid estrogens in surface waters. http://publications.environment-agency.gov.uk/pdf/SP2-T04-TR1-ep.pdf?lang)_e.

Appendix



PPL – pelletized poultry litter
RL – raw litter applications at rates of 23 Mg/ha (RL1) and 35 Mg/ha (RL2)
CT – conventional tillage
NT – no tillage
E1 – estrone
E2 – estradiol
E2_17S – estradiol 17 sulfate

Figure 1: Average flow-weighted concentrations of hormones in surface runoff from plots receiving pelletized (PPL) and raw poultry litter. Results include data from ELISA and LC/MS analysis.

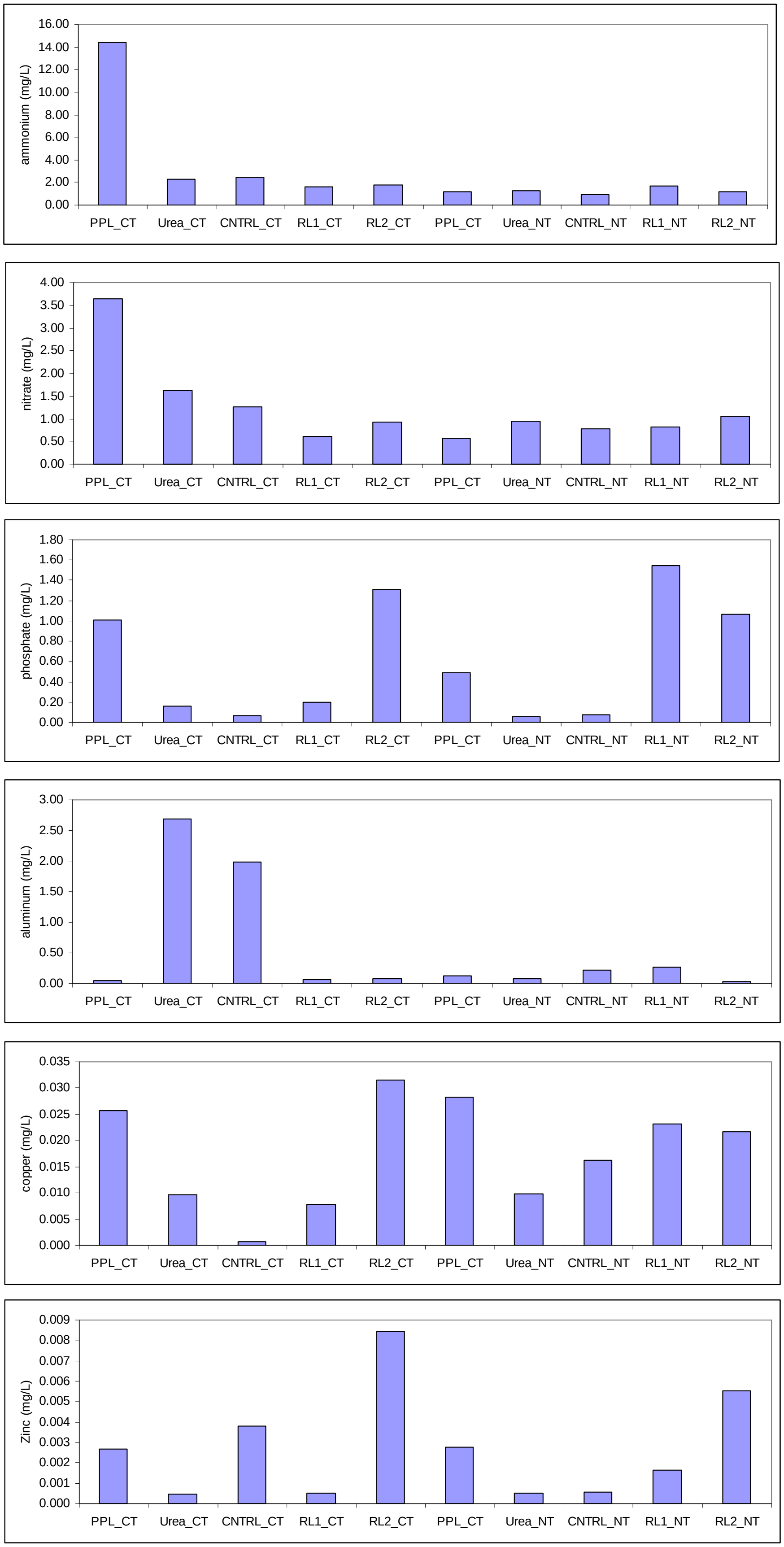


Figure 2: Flow-weighted concentrations of selected nutrients and trace metals in surface runoff from plots with various treatments. PPL – pelletized poultry litter; RL – raw litter applications at rates of 23 Mg/ha (RL1) and 35 Mg/ha (RL2); CT – conventional tillage NT – no tillage; CNTRL – control plot, no application.

POSTER PRESENTATIONS FROM THIS RESEARCH

- Dutta, S., S. Inamdar, J.T. Sims, A. Collins, and N Kiracofe. 2008. Nutrient and trace metal export in surface runoff from plots receiving pelletized broiler litter. 2008 Joint Annual Meeting, October 5-9, Houston, TX.

- Kiracofe, N., S. Dutta, and S. Inamdar. 2008. Comparison of pelletized poultry litter and urea for surface water quality. Delaware Water Resources Center (DWRC) Annual Poster session, May 2, 2008.

Nutrient and Trace Metal Export in Surface Runoff from Plots Receiving Pelletized Broiler Litter

Sudarshan Dutta[1], Shreeram Inamdar[2], J. Tom Sims[1], Alyssa Collins[1], and Nathan Kiracofe[2]

[1] *Plant & Soil Sciences;* [2] *Bioresources Engineering; University of Delaware, Newark, Delaware*

1. Introduction:

Pelletized broiler litter (PBL) is being increasingly recommended as a substitute to synthetic fertilizers like urea. The benefit of PBL is that it not only provides a nutrient source for the crops but also results in recycling and reuse of animal waste. This is especially critical for states like Delaware which face a surplus of animal wastes and manure from animal feeding operations. However, we know very little about the environmental impacts of PBL, especially for surface water quality. Thus, for PBL to be a environmentally sustainable alternative to commercial nitrogen fertilizers (e.g., urea), its impact on surface water quality needs to be evaluated.

2. Objective:

The objective of this study was to determine the concentrations of nutrients and trace elements in surface runoff from experimental plots receiving PBL and urea applications. **Mass exports** and **concentrations of nutrients – nitrogen (N) and phosphorus (P);** and **trace elements – Copper (Cu), Zinc (Zn), Aluminum (Al), and Iron (Fe)** were compared**.** Plot tillage treatments included **conventional** and **no-tillage**.

3. Study Site:

Fig.1: Location of study site (indicated by filled circle) on croplands in Middletown, DE.

Fig. 2: Experimental plots planted with corn.

Fig. 3: Sampling device at downslope edge of the plots to collect surface runoff samples.

Soil Type:

Matapeake silt–loam with 0 to 2 % slope.

Experimental plots: (Figure 4)

Six agricultural plots (12 m x 5 m)

Management Practices: (Table 1)
1) Conventional Tillage (CT) ;
2) No Tillage (NT).

PBL and Urea were applied to provide 252 kg/ha plant available nitrogen. This is a high rate of application, but is often used when corn yields are expected to be >10-12 Mt/ha. NT plots did not receive any tillage since 2004.

Collection of Runoff Water: **Samples were collected for six natural rainfall events** occurring on: June 20 and 29; July 5 and 17 and August 6 and 20, 2007. **Average mass exports and concentrations were determined for these six events**.

Initial nutrient and trace element concentrations of manure were also measured (Table 1). PBL was provided by Perdue AgriRecycle and the source of urea was Southern States Cooperative, Inc.

Acknowledgements:
This project was funded by USDA Conservation Grant, UD-CANR seed grant, and fellowship from the Avian Biosciences Center and the ISEQ at University of Delaware.

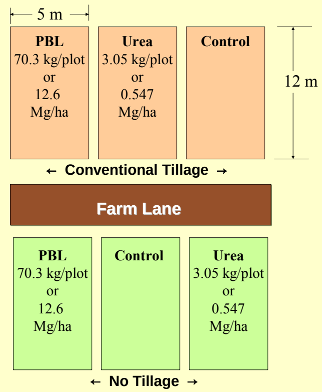


Fig. 4: Experimental plots with treatments.

Table 1: Nutrient and trace element concentrations in PBL (mg/kg):

NH_4–N	NO_3–N	T P
2165	1462	9192

Al	Fe	Cu	Zn
2021	1275	375	202

Urea content - 46% N and no P and K (Source: Southern States Cooperative, Inc.)

Table 2. Flow weighted concentrations (mg/L) from treatment plots:

Constituents Monitored	Conventional Tillage			No Tillage		
	PBL	Urea	Control	PBL	Urea	Control
NH_4 – N	9.89	2.60	1.20	7.66	3.12	2.47
NO_3 – N	2.62	2.64	0.81	1.33	1.73	1.65
Total P	0.82	0.06	0.03	3.49	0.67	0.02
Aluminum	1.69	0.72	0.48	0.49	0.88	0.48
Iron	0.73	0.31	0.21	1.06	0.44	0.18
Copper	0.013	0.008	0.001	0.002	0.004	0.003
Zinc	0.011	0.007	0.002	0.004	0.006	0.006

4. Results and Discussion:

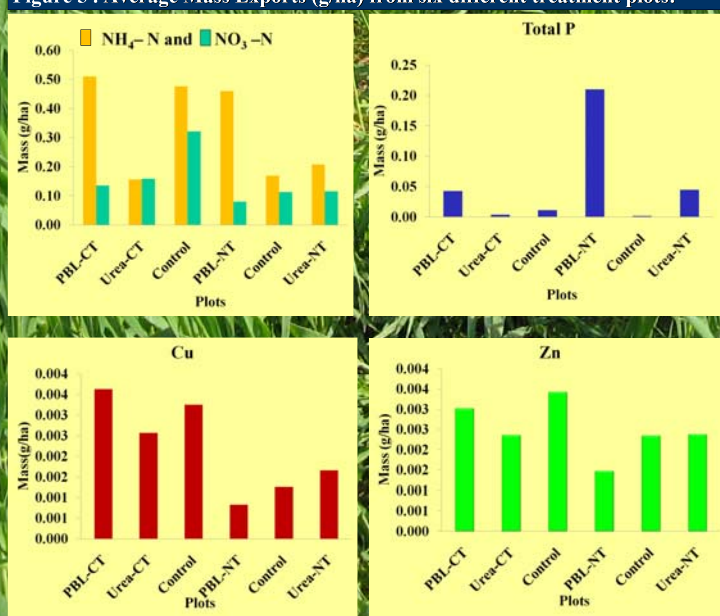
● The **Average Mass Exports** of nutrients and trace elements were **different** from **PBL** and **Urea** treated plots. Effects of different tillage practices were also observed.

● **Mass Exports** (Figure 5):-

❑ Nutrients:

➢ **NH_4–N** mass exports in surface runoff were **more** from **PBL** plots compared to urea treated plots under **both CT and NT** management practices. However, exports from the Control plot were also high. Compared to PBL, NH_3 losses to volatilization from urea are typically higher (Cabrera et al., 1993) and thus may explain the lower mass exports in runoff.

Figure 5 . Average Mass Exports (g/ha) from six different treatment plots:



4. Results and Discussion (*Contd..*)

➢ **NO_3–N** mass exports were **not significantly different** among **PBL** and **Urea** treated plots.

➢ Highest **Total–P** mass exports occurred from the **PBL–NT** plot. This might be due to the higher concentrations of P in PBL (versus urea) and the lower potential for P adsorption to soil in a no-tillage treatment.

❑ Trace Elements:

➢ Exports of Cu and Zn from **both PBL and urea** treated plots were very low.

➢ Maximum **Al** export was from **PBL–CT** plot. **Fe** exports were more from **PBL** applied plots (versus urea applied plots).

● **Flow Weighted Concentrations** (Table 2):

➢ **NH_4–N** concentrations were **more for PBL** treated plots than urea treated plots under both CT and NT management practices. NO_3–N concentrations were almost same. Total P concentrations were also more for PBL applied plots compared to urea.

➢ **Cu and Zn** concentrations **were very low** for all treatment plots.

➢**Al** concentration was highest from **PBL–CT** plot and **Fe** concentrations were **more** for **PBL** applied plots (compared to urea).

5. Conclusions:

● Overall, NH_4, Al and Fe exports were greater in surface runoff from PBL-treated versus urea-treated plots. However, it should be emphasized that our PBL application rate (252 kg N/ha) was at the high end of N rates used for corn in Delaware

● Management strategies such as incorporation of litter into the soil via localized tillage may help further reduce the exports of nutrients and metals in runoff.

● Exports and concentrations of Cu and Zn were very low and indicate that PBL may be as safe a N source for corn as urea and other N fertilizers, with respect to these trace metals.

6. References:

Cabrera, M.L., W. C. Merka, S. A. Thompson, S. C. Chiang and O. C. Pankorbo. 1993. Nitrogen transformation in surface-applied poultry litter: Effect of litter physical characteristics. Soil Science Society of America Journal 57: 1519-1525.

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Comparison of pelletized poultry litter and urea for surface water quality

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Department of Bioresources Engineering, University of Delaware, Newark, DE

Introduction

Excess nutrients in streams and lakes are a worldwide concern. Agricultural nonpoint source pollution is an important contributor. This excess in nutrients leads to an unsustainable increase in algae growth which in turns leads to algae decay and dissolved oxygen reduction in a process known as eutrophication. The main nutrients of concern are phosphates (P), nitrates (NO_3^-) and ammonia (NH_3). The Noxontown pond surrounded by St. Andrews school farms is currently suffering from excess nutrients and there is interest in exploring alternative, more sustainable fertilizers, in the hopes of reducing nutrients. With the advent of pelletized broiler litter (PBL) from the Perdue AgriCycle facility in southern Delaware, a new more sustainable and economical fertilizer option has become available. However the potential environmental impacts of PBL are still unknown. Thus, the purpose of this experiment was to compare the impacts of PBL and urea (traditional, commercially used fertilizer) on surface runoff water quality.

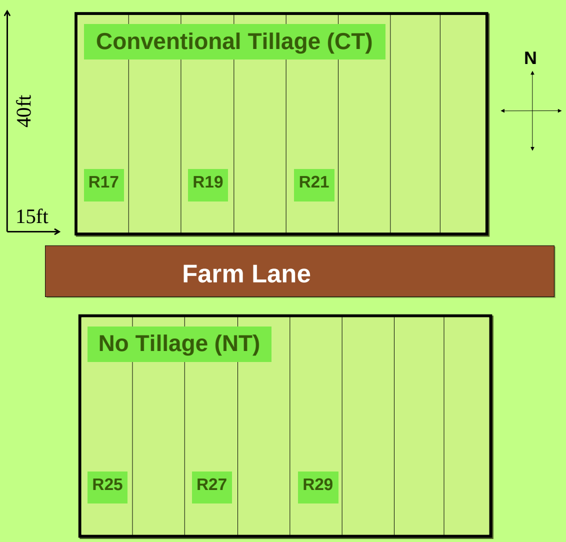


Figure 1: Selected plots for sampling

Figure 2: Sampling Device in field

Materials and Methods

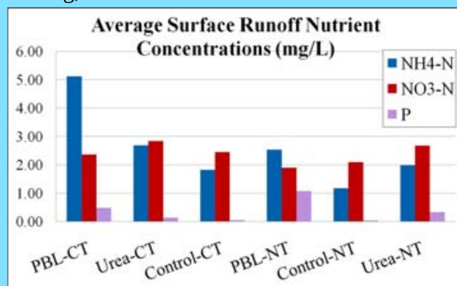
For this experiment a series of six plots were set-up at the St. Andrews farm in Middletown, DE. Three of these plots were conventionally tilled (CT) and three of the plots were in no-till (NT). The spatial arrangement of these plots is shown in Figure 1. The fertilizer application rates are presented in the table below.

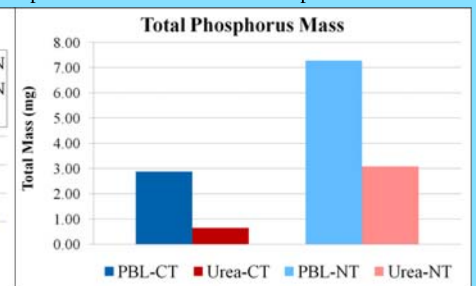
Plot #	Tillage	Nitrogen Source	Application (kg/plot)
R17	CT	PBL	70.4
R19	CT	Urea	3.05
R21	CT	Blank	0
R25	NT	PBL	70.4
R27	NT	Blank	0
R29	NT	Urea	3.05

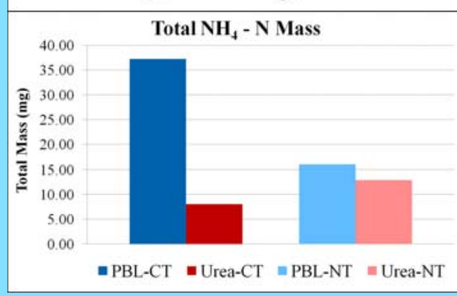
Surface runoff from plots was collected following natural rain events. Monitoring was performed over the summer of 2007. The plots were bounded by plastic edging and buckets were installed at the lower end of the plots to collect runoff (Figure 2). Rainfall amounts were determined from the DEOS rain gauge in Townsend, DE. Samples were collected in 250 mL Nalgene bottles and analyzed at the Soils Laboratory at UD.

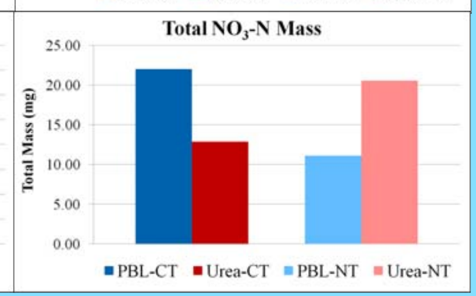
Results and Conclusions

A bar-graph of the average nutrient concentrations in the surface runoff can be found below. Using the values from this graph, a t-test analysis ($\alpha = 0.05$) was used to compare the average PBL concentrations to the average Urea concentrations across the different plot treatments. In addition to investigating the concentrations, an alternate comparison examined the total mass of each nutrient exported. The total mass was calculated with volume and concentration measurements per each rainfall instance and then summed and these values can be seen on the bar graphs below. In this analysis 8 of the 12 total samples were analyzed due to sample volume overflow however, in this calculations the control was not available for comparison due to an even greater excess of volume overflow. One final point of comparison was calculating the ratio of total rainfall in volume (excluding overflow cases) versus total rainfall in in. for each type of tilling, which was found to be 3.3 L/in for the CT plots and 5.3 L/in for the NT plots.









- In the t-test ($\alpha = 0.05$), no significant difference was observed for average nutrient surface runoff concentrations from PBL and urea treatments.
- Mass exports of total P and NH_4^+ in runoff were greater for the PBL plots versus urea-treated plots.
- Mass exports of total NO_3^- in runoff was greater for the Urea plots versus PBL-treated plots.
- These results suggest that PBL applications may have a greater potential for releasing nutrients in surface runoff. Alternative strategies – such as mixing of pelletized litter with surface soil or incorporation into the soil should be investigated to reduce the losses.
- This study was limited to surface runoff only. Future studies should investigate the sorption of nutrients from PBL to soil and loss with infiltration and subsurface runoff.
- The total rain ratio is higher for the NT plots than the CT plots, however because overflow events were more frequent in the CT plots this value is probably being underestimated. In future experiments larger sampling devices should be used to account for this sample overflow problem, since it also affects the total mass calculations