Report for 2005AR82B: The distribution of roxarsone and its byproducts in soils, soil pore-water, groundwater, and stream water

Publications

- Other Publications:
    - McKay, T. and C.B. Dowling, 2006, The effects of metal-rich poultry litter on the metal body burden of ground-dwelling arthropods: with notes on abundance (oral), The Society of Environmental Toxicology and Chemistry (SETAC), MidSouth Regional Chapter Annual Meeting, Jonesboro, AR.
    - McKay, T. and C.B. Dowling, 2006, The effects of metal-rich poultry litter on ground beetles, 80th Annual Meeting of the Southeastern Branch Entomological Society of America (oral), Wilmington, NC
    - McKay, T., C.B. Dowling, B. Gougeau, K.M. Williams, J.W. Klasky, J.S. Wright and K. Vanderpuye, 2005, Impact of poultry litter application on ground-dwelling arthropod populations (poster), Annual Meeting of the Entomological Society of America, Fort Lauderdale, FL.

Report Follows

Problem and Research Objectives

Problem

Most poultry litter from commercial poultry operations contains arsenic from the use of roxarsone, an organoarsenic feed additive. Because of the high nutrient content, poultry litter is reused as fertilizer for neighboring agricultural fields. The roxarsone in the poultry-litter fertilizer will degrade into both inorganic arsenic species [arsenite (As(III)) and arsenate (As(V))], and organic arsenic species [monomethylarsenic acid (MMA) and dimethylarseonic acid (DMA)]. The organoarsenicals (MMA and DMA) are produced by biomethylation via bacteria, fungi, and algae and are more toxic than their inorganic counterparts. Previous research indicates that the composting of poultry litter may release roxarsone and its by-products into the environment, which may impact soil and water resources from the accumulation of arsenic, other heavy metals, and nutrients over time.

Research Objectives

This investigation will characterize the mobility and concentration of roxarsone and its byproducts (inorganic and organic arsenic species) in poultry litter, soils, soil pore-water, groundwater, and streams in a small area on the Farm Complex at Arkansas State University. The transport pathway for roxarsone, As(III), As(V), MMA, and DMA in the environment will be determined.

Modifications to Research Objectives

Because a drought affected northeast Arkansas during the summer of 2005, no soil water or stream water samples were collected. Unfortunately, the contractors for the groundwater well, which was necessary for the proposed research, did not drill as agreed. The well was to be installed in late May/early June but the date was constantly pushed back. Ultimately, the well could not be drilled in a timely manner for last year's field experiments. Due to these setbacks, an additional experiment concerning the impacts of poultry litter on the plants and insect population was implemented. Soil, plant, and insect samples were collected on a weekly basis throughout the summer.

The arsenic speciation methods have not been reproduced yet in the laboratory. Because the arsenic species are not separating using the published methods on IC-ICP-MS, the samples were only analyzed for whole trace metal chemistry.

Methodology

Study Area

A 100 m x 100 m field located at Arkansas State University Farm Complex was divided into nine 20 m x 20 m plots. There were three control plots where litter was not applied (Plot A) and six treatment plots where poultry litter was applied (Plots B and C). Approximately 181kg of poultry litter obtained from a poultry house in Strawberry, AR was applied to each treatment plot.

Soil, plant, and insect samples were collected prior to poultry litter application. In addition, samples of the commercial poultry litter were collected. After poultry litter application, poultry litter, soils, plants, and insects were collected on a weekly basis and properly stored until analysis. Poultry litter from an organic farm in Bono, AR was collected in Fall 2005.

Insect Identification

All the insects that were collected were identified down to family; some were identified down to genus; and only a few were identified down to species. After identification, the insects were stored in 70% ethanol until analysis.

Digestion Experiments

Total arsenic concentrations of the samples were determined by digesting a subset of the samples. The samples were rinsed with 18 MΩ water and air-dried. The organic samples (e.g. poultry litter, insects) were digested using the procedure outlined in Garbarino et al. (2003). First, 30% hydrogen peroxide was added to the samples in a closed Teflon® beaker. Afterwards, the clear solution was evaporated and re-dissolved in concentrated nitric acid and hydrochloric acid, followed by heating to dryness. In the final step, the sample was dissolved in concentrated nitric acid, diluted with 18 MΩ water, and stored within their closed Teflon® beakers.

The inorganic soil samples were dissolved using concentrated hydrochloric acid, nitric acid, and hydrofluoric acid in closed Teflon® beakers. The digested samples were evaporated to dryness, re-acidified using ultrapure nitric acid, and stored within their closed Teflon® beakers.

Trace Metal Chemistry

To prepare the samples for ICP-MS trace metal analysis, the samples were further diluted with 18 MΩ water and again acidified with ultrapure nitric acid. The analyses were done on the Perkin Elmer DRC II ICP-MS with auto sampler at Arkansas State University according to US EPA Method 200.8 (Long and Martin 1991). A five-point calibration curve was created using standards traceable to NIST.

Principal Findings and Significance

Poultry litter does affect the geochemistry and ecology of the agricultural environment. Based on the ICP-MS data, the concentrations of trace metals such as arsenic, cadmium, and aluminum in insects, plants, and soils were elevated overall after the field application of poultry litter.

Certain insect communities changed after the poultry litter application. There was a population shift in ground-dwelling insect species (e.g., family: Carabidae) in response to poultry litter application. It is hypothesized that different Carabidae species were attracted to the odor of the poultry litter and overwhelmed the resident Carabidae population.

Further work needs to be done on the effects of poultry litter on the hydrology of an agricultural area (hopefully, when there is no drought!), and it is essential for the progress to be made on the IC-ICP-MS method for arsenic speciation.