Report for 2003DE32B: FATE AND TRANSPORT OF ARSENIC IN POULTRY LITTER AMENDED DELAWARE SOILS: IMPACTS ON WATER QUALITY

Publications

- Conference Proceedings:
    - Seiter, J., and Donald Sparks, 2006, Fate and transport of arsenic in poultry litter amended Delaware soils: Impacts on water quality, 18th World Congress of Soil Science, Philadelphia, Pennsylvania.
    - Seiter, J., and Donald Sparks, 2005, Fate and transport of arsenic in Delaware soils. Soil Science Society of America Annual Meeting, Salt Lake City, Utah.

Report Follows

INTRODUCTION AND OBJECTIVES

The Delmarva Peninsula is one of the most concentrated areas of poultry production in the United States. In 2000, 620 million broilers were produced, which resulted in manure and poultry litter containing approximately 2.6×10^4 kg of As. Arsenic occurs in poultry litter as a result of the use of 3-nitro-4-hydroxyphenylarsonic acid, roxarsone, a feed additive for prevention of coccidiosis, for increased weight gain, and improved feed efficiency. Through a series of processes the organic roxarsone is transformed into inorganic As species arsenite, As(III), and arsenate, As(V); these species are both more toxic than roxarsone. Arsenic concentrations in poultry litter has been found to vary from 0-77 mg kg^{-1}. The localized nature of poultry farming operations and the cost of transporting litter over long distances has led to limited land areas receiving repeated waste applications. This has raised concerns in the past over P saturation of soils, and similar concerns must also apply to trace element loading.

Phosphate, sulfate and other oxyanions are contained in mass quantities in the litter, and may out-compete arsenic species for adsorption sites on soil components. This competition is likely because phosphate is of similar structure and has the same affinity for oxides and clay minerals as arsenate. The source of sulfate in litter is alum, which is added to the litter in order to reduce soluble P. There is reason to believe that alum may also have an effect on As solubility.
Data are needed to understand the impacts that PL amendments have on the fate and transport of As in sandy, Mid-Atlantic soils and resultant effects on water quality. However, there are very limited data on the speciation and distribution of As in long-term PL amended soils, the fate and transport in these soils, and how competing ions such as phosphate, which is also found in large quantities in PL and in Delaware soils, affect As retention and release. Such studies are being conducted in this research and will be invaluable in understanding the fate and transport of As in soils that are quite fragile due to their sandy texture, low organic matter, clay and metal oxide contents, and the often high water tables.

Accordingly, the objectives of this study are:
1. To determine the As status, retention, and release in Delaware soils that have been amended and unamended with poultry litter (PL) and the effects of competitive sorbates such as phosphate
2. To determine the As status and speciation in poultry litter as a function of roxarsone treatment and time.

KEY FINDINGS IN 2005-2006 (FY05)

1. The basic physicochemical properties of the poultry litter amended and unamended soils were completed.
2. Arsenate sorption onto Delaware soils is highly influenced by pH. It appears that maximum As (V) adsorption occurs around the pH of the soil from pH 5.0-6.0. The adsorption isotherm data are currently being analyzed. Greater amounts of As(V) sorption was seen in the subsurface soils, than the surface soils. The maximum amount of As(V) sorption, as a percent of the total amount added, ranged between 15-25%

3. Data on the poultry litter analyses are included in Table 1. Total As levels range from 2.6 to 15.1 mg/kg. XANES analysis has provided information on As speciation in the poultry litter samples (Figure 1). Preliminary data indicate that there are mixed As species in the litter samples with the primary species being As(V).

PLANS FOR 2006-2007 (FY06)

Competitive studies will be conducted using a stirred-flow method. Phosphate and arsenate will be the oxyanions of concern. Three different studies will be conducted to assess the ability of As to adhere to soil particles when phosphorus is present. First, As will be sorbed onto the soil, then P will be introduced into the system. The amount of As released from the soil will be monitored. The other study that will be conducted will assess the ability of As to remove P from the soils. Additionally, a study will be conducted where As and P are introduced to the soil together but at varying As:P ratios (1:1, 1:100, 1:1000).

Table 1.
Arsenic Status of Poultry Litter Samples as Affected by Roxarsone Treatment

	----------Feed----------		---------- Litter ----------					
Age (days)	Treatment	ROX (mg/kg)	Total As (mg/kg)	Water Soluble As (mg/L)	Total P	Water Soluble P (mg/L)	pH	Moisture Content %
0-16	Starter	2.7	2.6	0.4	2796.4	557.6	8.4	12.8
17-31	Agristats 1	13.3	12.0	11.8	4258.4	1131.1	8.6	19.5
32-37	Agristats 2	0.6	15.1	7.8	8906.9	1241.4	8.8	14.8
38-44	Agristats 3	0.3	12.8	7.8	8701.2	1719.0	8.8	16.4

Figure 1. XANES analysis of Poultry Litter Sample