

**Report for 2003DE32B: Graduate Fellowship in Water Quality:
Fate and Transport of Arsenic in Poultry Litter Amended
Delaware Soils: Impacts on Water Quality**

There are no reported publications resulting from this project.

Report Follows

Project Justification and Objectives:

There are increasing concerns about surface and ground water quality in the Mid-Atlantic Region of the USA. The primary pollutants of concern on the Delmarva Peninsula have been nutrients such as N and P, but there are ever increasing concerns about trace metals derived from industrial, municipal, and particularly, agricultural sources. Arsenic (As) is a ubiquitous metalloid in soil/water environments due to natural geological processes and anthropogenic inputs. Over the past few decades, environmental health has been jeopardized by As contaminating soil and water in the U.S. because of its high carcinogenic, phytotoxic and biotoxic characteristics. Arsenic is a major concern for the health of plants and crops, microorganisms, farm animals, wildlife, and humans. Long-term human exposure to As in drinking water can result in bladder, lung, skin, kidney, immunological, neurological, and endocrine effects. The USEPA announced that it was lowering the maximum contaminant level (MCL) for As in drinking water from 50 ppb to 10 ppb, and all water systems must comply by January 2006 (USEPA, 2001a). This will necessitate an ever vigilant monitoring of water quality to ensure that human health is not deleteriously impacted. Recent data show that there is still an unacceptable level of risk at the EPA's newly adopted 10 ppb MCL. It has been shown that the consumption of only 3 ppb of As creates risk of bladder and lung cancer in 4 to 10 people per 10,000 people (National Research Council, 2001). This risk level exceeds EPA's maximum acceptable level of risk of 1 in 1,000,000 people by 1000-fold.

The Delmarva Peninsula is one of the most concentrated poultry production areas in the US. In 2000, 620 million broilers were produced, which resulted in manure and poultry litter (PL, a mixture of bedding such as wood shavings or sawdust and manure) containing approximately 2.6×10^4 kg of As (Poultry and Value Summary, 2000; Garbarino et al., 2003). Poultry litter is generally applied at the rate of 8.96-20.16 Mg ha⁻¹ on agricultural lands, and its total annual As inputs on the Delmarva Peninsula are estimated between 20 and 50 metric tons of total As (Christen, 2001a). The As in the PL is initially primarily organic (3-nitro-4-hydroxy-phenyl-arsonic acid, Roxarsone, abbreviated ROX), which is the form fed to the poultry to control coccidiosis disease, to enhance growth and to improve feed conversion. The quantity of roxarsone that is excreted by a single broiler when fed the 45.4 g ton⁻¹ formulation is estimated to be 150 mg over the typical growth period of 42 days for the chicken (Garbarino et al., 2003). Feed spillage and digested materials have increased the mean total As concentration in the PL to 14-76 mg kg⁻¹ (Moore et al., 1998). Assuming that PL is applied at a rate of at least 5 metric tons per hectare, about 60-250 g of As per hectare could be introduced with each PL application. Annual total metal(oid) inputs on agricultural lands via PL amendments are not specifically regulated at either the federal or state levels, and continuous PL amendment effects on As contamination in Mid-Atlantic soil and water environments are not known. Moreover, the effects of PL amendments on trace element contamination, e.g., from As, in soils have not been considered in current nutrient management programs.

The As in PL is water soluble, which suggests that after land application, it could be readily mobile in water environments. Limited data have shown ground water from agricultural fields of the Pocomoke River Basin in MD and DE having total dissolved As concentrations as high as 23 µg L⁻¹ (Hancock et al., 2003). There is evidence that the organic As transforms to inorganic As, primarily As (V), after land application. The As (V) is much more toxic than ROX. 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 Delaware soils, the fate and transport of As 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 will

be 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 transport of As in PL amended and unamended soils as it impacts water quality.