Examination of Estrogenic Chemical Behavior for Determining Potential Off-Field Migration from Dairy Manure to Texas Waters

Project Leaders

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Project Needs, Description and Expected Outcomes

The potential impacts of hormonal compounds on human health and wildlife communities are extensive. Evidence suggests estrogenic compounds found in animal waste induce breast cancer (Dickson et al. 1986), while reduced sperm counts and increased testicular cancer rates have been linked to environmental exposure (Carlsen et al. 1995). Natural estrogen compounds have also been documented to cause sex reversals in fish (Nakamura 1984), premature heifer development (Shore et al. 1988), and wildlife reproductive disorders (Kramer et al. 1998). The potency of hormonal compounds presents a further concern, as concentrations as low as 0.1 ng 17ß-ethinylestradiol/L have been found to cause reproductive problems in fish (Sumpter & Jobling 1995).

Land application of manures presents an environmental loading of estrogens that may result in regional surface or ground water concentrations significantly above ambient levels. Elevated concentrations of excreted steroidal compounds have been recognized in livestock waste (Mathur & Common 1969) for some time, but environmental impacts continued unrecognized. Recent concerns over hormonal exposure warrant further research on the fate and transport of these chemicals following land application of animal wastes.

Despite numerous physiological investigations, literature on the fate and transport of steroidal compounds in environmental systems is limited. Research has begun to address this issue from a monitoring standpoint, but essentially no examination of specific chemical behavior (degradation, sorption, etc.) exists. Nichols et al. (1997, 1998) found 17 ß-estradiol migrates off-site when broiler litter was applied at agronomic rates. However, the monitoring aspect of these studies did not permit evaluation of degradation, sorption, or leaching on hormone concentration. Furthermore, the focus of the studies has centered on one compound, 17ß-estradiol, and other estrogenic compounds (e.g., estrone, 17α-ethynylestradiol) have been essentially ignored.

Monitoring 17β-estradiol in broiler litter disregards both other hormones (i.e., metabolites) and other animal waste management systems. Furthermore, different soil types receiving animal waste should be investigated due to matrix influence on chemical mobility. By increasing the analytical rigor of chemical fate and transport using new and emerging techniques, a better understanding of the hormonal behavior will be achieved. Using an approach that progresses beyond rapid assessment methods for 17β-estradiol will provide more accurate and precise determination of estrogenic risk to human and wildlife populations.

The research proposed here will begin to investigate the behavior of estrogenic

compounds inherent to dairy waste. The Pesticide Fate Research Laboratory at Texas A&M University has performed numerous studies investigating herbicide behavior, chemicals that resemble hormonal compounds in structure and will hence require similar methodologies. Furthermore, an influx of concentrated animal feeding operations (CAFOs) has magnified problems related with handling animal by-products in Texas. This combination of facilities, expertise and proximity to areas at risk presents an ideal situation to study these chemicals. Objectives for this study include:

- Identify primary metabolites of 17β-estradiol and relative concentrations present in dairy lagoon effluent.
- Evaluate sorption characteristics and leaching rates of 17β-estradiol and metabolites in soils receiving dairy manure and wastewater.

Experimental design

Although primary metabolites have been identified in municipal waste streams, livestock waste remains uncharacterized. The proposed project will focus on sampling dairy waste streams, as initial investigations have shown elevated estrogenic activity associated with dairy operations (Raman et al. 2001). Samples will be taken at currently cooperating dairy operations in East central Texas. Analysis of raw excreta, lagoon wastewater and pumped effluent designated for land disposal will be performed. Lagoon sampling will follow the procedures developed by the investigators of this proposed research in the Texas Animal Manure Management Issues research group (Mukhtar et al. 2001). These samples will be used in the following objectives.

- Identify primary metabolites of 17β-estradiol and relative concentrations present in dairy lagoon effluent.

Lagoon samples will be analyzed using a GC-MS (Varian Saturn 3) to determine the total estrogenic concentration and identify the corresponding compounds. Quality assurance/quality control will be conducted as outlined by EPA QAPP protocols. This method provides currently unexamined baseline concentrations and improves upon the use of enzyme-linked assay kits utilized by previous studies to determine the presence of 17β-estradiol as an indicator compound. Assay tests present a number of drawbacks associated with this technique; including cross contamination and inadequate identification of metabolites.

- Evaluate sorption characteristics and leaching rates of 17β-estradiol and metabolites in soils receiving dairy manure and wastewater.

The principal metabolites will then be used to determine adsorption characteristics in soils representative of Texas dairy operations. The isotherms for the key metabolites will be determined using the indirect batch-suspension measurement procedure. In conjunction with the jar adsorption experiments, leaching chambers will be used to determine the leaching properties of the key metabolites. Agronomic disposal rates of lagoon effluent will be added to the column and representative rainfall rates will be simulated to determine effective leaching.

Work Plan:

1. Purchase GC columns with associated supplies and equipment by June 15
2. Take samples from all dairy facilities by July 15
3. Finish estrogenic compound identification by August 30
4. Report findings on sorption experiments by October 15
5. Use results to obtain grant money for degradation and field studies

Expected Outcomes:

This study provides an important first step in characterizing the transport of estrogenic compounds from livestock operations to surface and ground water systems. The proposed research will provide a foundation upon which further investigation into degradation rates and field transport will be based. Data collected from this initial examination will allow for leverage in obtaining additional funding from federal and state agencies. The long term goal of this research will then be achieved in providing an understanding of the chemical behavior of estrogenic compounds in the environment for aid in best management practice development to limit the transport of these compounds to waters of concern.