Determination of Feedyard Evaporation Using Weighing Lysimeters

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Background

The Texas Panhandle and southern Great Plains are the largest cattle feeding region in America, producing more than 7 million fed cattle per year. These feedlots are responsible for 30% of the nation's fed cattle production. Along with animal manure, substantial amounts of feedlot dust are also generated by the feedlots, occasionally creating nuisance conditions for neighbors and communities. One widely accepted method for controlling feedlot dust is sprinkler irrigation. However, agricultural demand on the vital Ogallala Aquifer continues to increase and threaten the aquifer's long-term sustainability. It is imperative that every effort be made to use existing water as efficiently as possible.

Dry feedyard surfaces favor dust emissions, while too much moisture favors odor production. Knowing How Much Water to apply is key. The feedlot lysimeter project attempts to quantify daily moisture loss from feedlot surfaces due to evaporation. Then correlating NPET (North Plains EvapoTranspiration) climatic data with evaporation rates may yield a water management tool for feedlot managers. Together, the two will provide a policy-analysis tool that will help authorities predict the water-resource impact of any policy that might require feedyards to adopt sprinkler dust control as the "Best Available Control Measure," or BACM.

Methods & Materials

The manure lysimetry project consists of six small, weighing lysimeters installed at the North Plains Research Field near Etter, TX, which simulate the cattle feedyard surface.

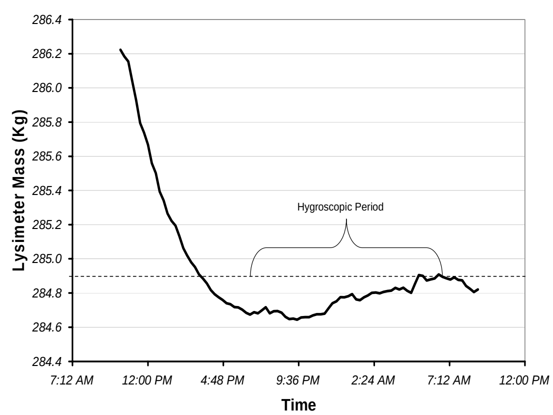
The lysimeter pans are packed with a typical Panhandle soil and topped with cattle manure scraped from fly ash-surfaced pens. The manure surface is wetted to a target moisture content of 30% (wb) and placed on its respective scale. A PC-based data-acquisition and control (DAQ/C) system continuously weighs the pans, and decreasing mass of the lysimeters is attributed to evaporative loss. The DAQ/C software then calculates this daily loss and automatically replaces the evaporated water each morning with a micro-irrigation system. The lysimeter scales can resolve increments of mass equivalent to 1/100th of an inch of precipitation.

The daily water lost to evaporation is termed pan evaporation, or E_p. These E_p values are compared to daily reference evapotranspiration (Et_o) values produced by the NPET (North Plains EvapoTranspiration) network. If correlated, ET_o values could be used to determine E_p values.

Preliminary Results & Discussion

Evaporation data were collected from the summer of 2003 to the summer of 2005. Values for lysimeter evaporation ranged from 0 to 4.3 mm per day. In general, lysimeter data have shown that E_p and Et_o are poorly correlated. However, a moderate correlation has occurred during cooler periods. Limited cool season data indicated that E_p was approximately 30% of Et_o. Little or no correlation was indicated for warmer season data. This is likely due to the transpiration component of Et_o associated with vegetative cover. Transpiration has less impact upon Et_o during cooler temperatures because plant growth is slowed.

Continuous monitoring of lysimeter mass revealed a slight gradual increase in mass following intense periods of manure drying. The period in which manure absorbs moisture from cooler, more humid air has been termed the “hygroscopic period” and occurs during early morning hours.



The interfacial layer is a compacted soil/manure complex which occurs between lower manure layer and the subsoil. This layer restricts water transport and forms regardless of soil type. An experiment was conducted in the summer of 2005 in which three the lysimeter pans were packed with a constructed interfacial layer and three without. After a significant rainfall, pans without an interfacial layer evaporated more water than pans containing one. This excess water seeped into the subsoil of pans without an interfacial layer while it remained above the layer in pans containing one. Evaporative forces were able to extract this moisture as well as moisture contained in the subsoil. However, less evaporation was observed in pans containing an interfacial layer because moisture was largely extracted from manure above the interfacial layer.

Data suggest that the limiting hydraulic properties of the interfacial layer play an important role in evaporation from feedlot surfaces. Although a warm season correlation between E_p and Et_o has not been determined, it is likely that the modified Penman-Monteith equation used to calculate Et_o could be modified to extract the transpiration component resulting in an equation tailored more to evaporation associated from a soil surface.

Current Status & Future Plans

The lysimeter project is currently being updated with new, more robust weighing deck scales.

Both verification and new experiments are planned for the manure lysimetry project. One such new experiment will study the relationship between surface temperature and rate of evaporation. Surface temperature will be measured using infrared photography and compared to evaporation rates determined by change in lysimeter mass. Armed with increased technology, the manure lysimetry project will play a vital role in understanding water movement through manure surfaces.