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ScienceDirect
Bioresource Technology 98 (2007) 745–752
BIORESOURCE TECHNOLOGY

# Impact of dairy housing practices on lagoon effluent characteristics: Implications for nitrogen dynamics and salt accumulation

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Received 4 November 2005; received in revised form 3 April 2006; accepted 3 April 2006
Available online 19 June 2006

## Abstract

Increasing emphasis on maintaining environmental integrity by dairy operations warrants examination of management influence on waste characteristics. Complete profiles of anaerobic dairy lagoons for eleven operations in central Texas, distinguished by use of dry-lot and hybrid (i.e., facilities comprised of free stalls with smaller dry-lot areas) management systems, were analyzed for 15 physicochemical parameters. Although solids, pH and TKN values were similar between housing type, statistical differences in $NH_4$-N, P, K, Mg, Na, Mn, Cu and electrical conductivity (EC) were observed. The discrepancies were attributed to dissimilar cattle activity, where cows spend more time near flush alleys in hybrid systems than dry-lot systems, which facilitates waste transport to anaerobic lagoons. These results suggest a possible difference in N dynamics between lagoon types, which in turn would have implications for $NH_3$ volatilization. Potential salt-stress impact on both lagoon effectiveness and pastures receiving land-applied lagoon effluent may also be enhanced by hybrid systems. This study not only contributes data on anaerobic lagoon characteristics, but also provides additional considerations for dairy producers striving to meet more rigorous regulations while attempting to protect soil resources for crop production.


*Keywords:* Anaerobic lagoon; Manure management; Dairy housing; Nitrogen dynamics; Ammonia emissions; EC; Salinity

## 1. Introduction

Livestock producers have received increased attention by environmental regulatory agencies, prompted in part by problems incurred by the trend toward intensive operations concentrated in small geographic areas. In particular, dairies have undergone greater scrutiny in some locations because of potential water quality degradation (Arnold and Meister, 1999), odor generation (Rabaud et al., 2003) and atmospheric pollution (van Calker et al., 2004). Furthermore, as many operations depend on land application for manure and water disposal, land use impacts should be considered to protect soil resources for sustained pasture productivity and crop yield. Therefore, it is important that dairy managers consider potential management options to protect their resources and meet more rigorous environmental regulations.

Agriculturally generated $NH_3$ volatilization has been identified as a pollutant of concern, as excessive emissions have been attributed to eutrophication (Paerl, 1995; Paerl and Whitall, 1999) and soil acidification (Roelofs et al., 1985). Reducing $NH_3$ volatilization can aid in limiting odor production (Ullman et al., 2004) while concurrently improving animal health (Al Homidan et al., 2003). Volatilization also represents a N loss that could otherwise act as a fertilizer during crop or pasture cultivation. Therefore, the transfer of N in animal manures to the atmosphere warrants further research on N dynamics in different livestock management systems to help alleviate environmental degradation.

Although concern over $NH_3$ emissions from dairy operations has prompted increased emphasis on understanding mechanisms that influence N dynamics, further research

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0960-8524/$ - see front matter 
doi:10.1016/j.biortech.2006.04.005

remains to investigate basic management practices that reduce emissions. Decreasing dietary N reduces production of urinary urea concentration, resulting in lower $NH_3$ emissions (Smits et al., 1995; Frank et al., 2002). However, barn design and farm management should be considered for further emission suppression and by operations with restricted feed regimes (Monteny and Erisman, 1998). For instance, Dewes (1999) found that solid manure systems offered lower $NH_3$ emissions over longer time periods compared to liquid management systems. However, for dairy producers who have established liquid management systems, the extent to which flush water transports waste to treatment lagoons presents another potential case that may alter the N regime of the facility.

High salinity can also be a problem for some dairy operations. Elevated salt concentrations can adversely impact lagoon function through the inhibition of bacterial activity (Safley et al., 1993). Furthermore, increased salt concentration in the soil solution can negatively impact plant growth and decrease pasture productivity. High salinity can depress nutrient-ion activity, resulting in specific nutrient limitations, osmotic impediments and other physiological disorders (Grattan and Grieve, 1999). Accumulated salt occasionally impacts irrigated agriculture, particularly in areas experiencing poor drainage or exhibiting shallow groundwater tables (Dinar et al., 1991). Regions with high transpirational demands can aggravate salt-stress related to crop growth. Therefore, dairies in these geographical locales may be at risk when applying lagoon effluent on pastures, as either irrigation or for disposal.

Dairy operations in Texas typically employ either dry-lot or hybrid facilities. Dry-lots consist of non-vegetated open lots (i.e., corrals) used as the primary cow housing method with feed provided along alleyways. Producers historically have accepted these systems as an economically favorable means of housing. Relatively small financial requirements exist for structure construction and maintenance, as only simple overhead shades offer protection from extreme weather conditions. In contrast, hybrid facilities utilize smaller dry lots and loafing areas in conjunction with free stalls (resting cubicles or beds in which dairy cows are free to enter and leave). This housing system has become increasingly popular despite greater construction and labor costs (Stokes and Gamroth, 1999). Benefits associated with hybrid facilities can offset these expenses by providing better protection from inclement weather and reduced exposure to mud. The corresponding improvement in cow comfort has been shown to enhance milk production, lower culling rates and increase body weight of culls (Stokes and Gamroth, 1999). Inherent to the designs of these different systems, lagoons receiving effluent from hybrid facilities typically receive a greater organic load than lagoons associated with dry-lot operations.

This paper functions as an extension of an assessment conducted to discern potential management impacts on dairy lagoon performance (Mukhtar et al., 2004). In this portion of the research, emphasis was placed on identifying differences in primary anaerobic lagoon physicochemical characteristics resulting from distinct housing practices. The aim of this study was to determine the environmental repercussions dairy producers may encounter depending on the implementation of dry-lot versus hybrid housing facilities.

## 2. Methods

Eleven primary anaerobic lagoons in the central Texas counties of Erath (6 lagoons), Comanche (3 lagoons), and Hamilton (2 lagoons) were examined for discrepancies in physicochemical properties (Fig. 1). Five operations exclusively employed dry-lot management, while the remaining six facilities utilized hybrid systems. The lagoons ranged from 6 to 14 years of age and serviced dairy operations comprised of 200 to 2500 cows. Hybrid systems used sand or composted manure as bedding material in the free-stall barns. The lagoons received waste from a variety of sources, including feed alleys, milking parlors, holding pens, and open lots. Mukhtar et al. (2004) examined the impacts imparted by these factors and found no statistical significance linking these variables to lagoon physicochemical characteristics.

A flat bottom boat was used to navigate each lagoon along the midline. Lagoon slurry samples were taken at five locations within each lagoon, situated at regular intervals from approximately 6 m downstream of the inlet to the lagoon center. Samples were collected with the "Sludge Judge" (Nasco, Fort Atkinson, WI), a sampling device consisting of three 1.5-m sections of 3.2-cm diameter acrylic pipe and a ball check valve at the bottom end. The sampler was lowered slowly until it rested on top of the dense material at the bottom of the lagoon, filling the pipe and providing a composite of the lagoon profile which can reasonably be pumped following agitation. The sample was subsequently emptied into a plastic bucket, mixed thoroughly to simulate an agitated mixture of supernatant and sludge, and stored in a 1-L plastic bottle. The samples remained in an ice-filled cooler during transport and kept

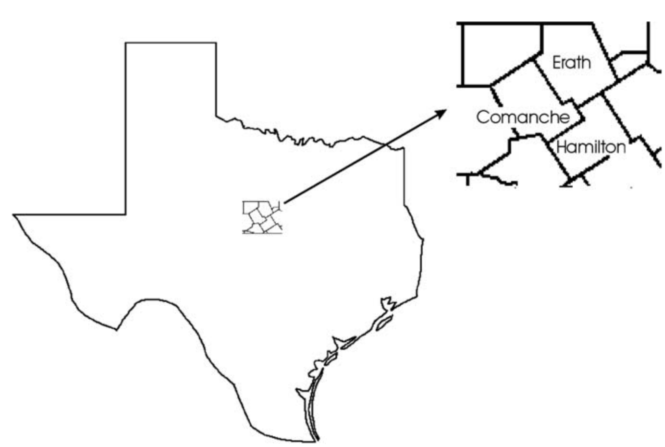


Fig. 1. Dairy lagoon locations in the counties of Erath, Comanche and Hamilton in central Texas.