NITROGEN LEACHING FROM DAIRY PASTURES IN THE NORTHEAST UNITED STATES

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ABSTRACT

While intensive grazing has the potential to increase dairy farm profitability in the Northeast United States, the uneven recycling of N through feces and urine can increase NO_3^- leaching. We measured NO_3^- leaching loss from urine and feces beneath N-fertilized orchardgrass using 60 cm diameter by 90 cm deep drainage lysimeters. Mean NO_3-N levels in leachate beneath these areas were 3.8, 6.5, 93.5, 110 and 139 mg l^{-1} for the control, feces, and spring, summer and fall applied urine. Extrapolation of the leaching data over a grazed landscape indicates that a grazing intensity for a 180-day grazing season in the order of 240 animal (mature Holstein cow) days (AD) ha yr^{-1} will result in a leachate of 10 mg l^{-1} of NO_3-N (the U.S. EPA Drinking Water Standard) under pasture fertilized with 220 kg N ha^{-1}.

KEYWORDS

Grazing, grassland, groundwater, water quality, orchardgrass

INTRODUCTION

To maintain dairy farm profitability in the face of rising fuel and machinery costs, tighter environmental constraints, and decreasing Federal support, some researchers and extension specialists in the Northeast United States are advocating inclusion of intensive grazing as a component in dairy production systems for this region (Fales et al., 1992). Such systems have been the mainstay of dairy production in the temperate maritime climates regions Europe and New Zealand for many years. While intensive grazing systems have the potential to increase farm profitability in the Northeast (Emmic and Toomer, 1991; Parker et al., 1991), the high rates of N used in these systems and the uneven recycling of this N through feces and urine in pastures has increased NO_3^- leaching from pastures in other parts of the world (Ball et al., 1977; Ryden et al., 1984; Steenvoorden et al., 1986). Because intensive grazing is likely to become an important component of dairy production systems in the Northeast United States, its environmental impact needs to be evaluated in the temperate continental climate of this region of the world.

MATERIALS AND METHODS

Since the three major sources of NO_3^- leaching loss from pasture to the groundwater are from fertilizer N, urine, and feces; we measured NO_3^-- leaching loss beneath N-fertilized orchardgrass (Dactylis glomerata L., cv. Pennlate) using 60 cm diameter by 90 cm deep drainage lysimeters. The lysimeters were part of an intensive grazing study on a limestone derived Hagerstown silt loam soil (Typic Hapludalf: clayey, mixed, mesic) located adjacent to the Penn State Dairy Research Center near University Park, Pennsylvania. There were five replications of five treatments in the lysimeters: a control receiving no urine or feces; urine after the first spring grazing; urine after a mid-summer grazing; urine after the last fall grazing; and feces after a mid-summer grazing. Over the three years of the study all lysimeters received an average of 242 kg ha^{-1} of N as NH_4NO_3 split into several applications plus recommended P and K. Urine application was 3 l collected from animals grazing the pasture, and feces treatment was 2 kg collected from the same animals. The urine and feces were collected while the animals were in the barn for milking.

Data collection was started in April 1993 and continued until March 1996. Leachate was collected weekly or after major storm events, volume recorded, and samples taken for NO_3^- analysis by ion chromatograph. Leachate data was summarized over the water year of April to March and extrapolated over the pasture area using a negative binomial distribution (Peterson et al., 1956) to account for overlap of multiple urine and feces deposition modified for higher stocking rates common in intensive grazing systems (Richards and Wolton, 1976).

RESULTS AND DISCUSSION

For the three years of the study period, mean NO_3-N levels in leachate beneath the control, feces, and spring, summer and fall applied urine were 3.8, 6.5, 93.5, 110, and 139 mg kg^{-1}. Nitrate concentrations tended to peak in late fall to early winter when water again began to leachate after the growth and evapotranspiration stopped due to cool weather (Figure 1). Overall more NO_3-N nitrate was leached from beneath the fall applied urine than all other treatments (Figure 2). For the first two years of the study more NO_3-N was leached from beneath the spring applied urine than from beneath the fall, but by the last year of the study the cumulative amounts of leached NO_3-N for these two treatments were the same. This was due to a very dry summer in 1995, when grass growth in the lysimeters was greatly reduced. Consequently, less urine N was taken up by the grass in the lysimeters and was available to be leached in the late fall and winter.

Extrapolation of the leaching data over a grazed landscape indicates that a grazing intensity for a 180-day grazing season in the order of 240 animal (mature Holstein cow) days (AD) ha^{-1} yr^{-1} will result in a leachate of 10 mg l^{-1} of NO_3-N under pasture fertilized with 240 kg N ha^{-1}. This AD number is controlled in large part by the projected baseline NO_3-N leaching rate of 3.8 mg l^{-1} under an entire grazed landscape and urine deposition.

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Figure 1
Nitrate concentration in lysimeters from May 1, 10, 1993 to March 31, 1996.

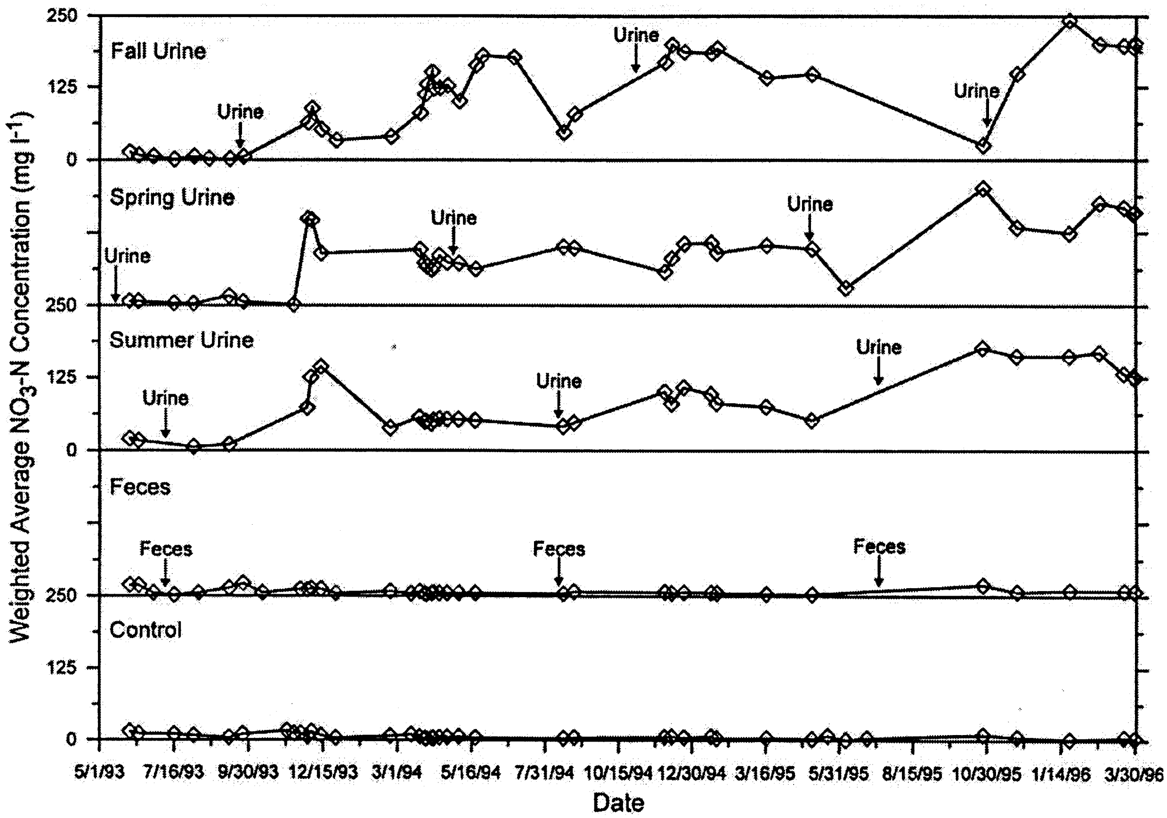

Figure 2
Cumulative nitrate loss in lysimeters from May 1, 1993 to March 31, 1096.