GROUNDWATER CONCENTRATIONS OF NON-NITROGEN NUTRIENTS UNDER A MEDIUM FERTILITY PASTURE SYSTEM

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ABSTRACT
The purpose of this multi-year study was to determine concentrations and transport of non-nitrogen nutrients in groundwater under a medium fertility pasture system. Rotationally grazed grass pastures received 56 kg N/ha annually as NH_4NO_3 for a 5-yr period. A topsoil pH of 6.0 and available P and K levels of 28 and 168 kg/ha, respectively, were maintained. Concentrations of P, K, Na, Ca, Mg, and Cl were measured in water from springs draining each paddock. Nutrient concentrations did not vary greatly on a monthly basis but there some increases during the second 5-yr period when annual N fertilizer rates were 168 kg/ha. Concentrations of K and Na changed very little; Mg changed little until the second 5 yrs when it increased gradually; Cl decreased slightly during the first 5 yrs and then increased rapidly during the second 5 yrs; P levels were low and decreased slightly throughout the study.

KEYWORDS
Calcium, leaching, magnesium, nutrients, potassium, sodium, subsurface flow

INTRODUCTION
The leaching of nutrients is of increasing concern, not only for the economic loss, but also because of the potential detriment to groundwater quality. Most nutrient leaching studies have focused solely or primarily on nitrate (NO_3) leaching. Non-nitrogen nutrients in grasslands have been studied for their concentrations in the forage and the impacts of fertilization upon those concentrations, e.g. Hopkins, et al. (1994). Grassland studies which evaluate non-nitrogen nutrients in soil and water in these systems are limited. A rotational grazing study in Nebraska indicated that the presence of cattle at the time of runoff increased the nutrient concentrations in the surface runoff compared to when cattle were not present (Schepers and Francis, 1982; Schepers, et al., 1982). In New Zealand studies, Steele, et al. (1984) reported one year of data on seven nutrients in water collected with suction samplers from cattle grazed pastures, and Heng, et al. (1991) reported concentrations of seven nutrients in mole-tile drainage under sheep pastures for two years.

METHODS
This study was conducted on a 17.2 ha area, divided into four paddocks, at the North Appalachian Experimental Watershed near Coshocton, Ohio. The vegetation was predominantly orchardgrass (Dactylis glomerata L.) and Kentucky bluegrass (Poa pratensis L.). A spring calving herd of 25 Charolais beef cows grazed the pastures rotationally during the summer (May-October) and were fed hay, grown elsewhere on the station, in one pasture during the dormant winter period (November-April). Each paddock was fertilized with NH_4NO_3 at an annual rate of 56 kg N/ha for 5 years, and the rate was changed to 168 kg N/ha for the next 5 years. A topsoil pH of 6.0 and available P and K levels of 28 and 168 kg/ha, respectively, were maintained by applying fertilizer based on annual soil tests. Further management are described by Owens, et al. (1982, 1992).

Pasture slopes ranged from 12 to 25%, with an average of about 20%. Soils are well-drained residual silt loams (Typic Dystrochrepts and Hapludults). Soils, climate, geology, and geomorphology of these areas have been described by Kelley, et al. (1975). Subsurface flow was handsampled weekly at springs on outcrops of nearly impermeable clay, that maintain perched aquifers. The quantity of subsurface flow was calculated using lysimeter water budgets (Van Keuren et al., 1979).

Water samples were analyzed for soluble Cl (Sol Cl) by electrometric titration (Piper, 1947). Soluble Ca, K, and Na were measured by flame photometry. Soluble Mg was determined by atomic absorption spectrophotometry. Total P (Tot P) was measured colorimetrically in acid-treated samples by modified phosphomolybdate procedures (USEPA, 1979). Total organic C (TOC) was the difference between total C and total inorganic C as determined with an infrared C analysis system (Oceanography International Corp.).

Chemical data were tabulated on a seasonal basis corresponding to the cattle-management treatments, i.e. a growing-grazing period (May-October), and a dormant-feeding period (November-April). The transport of each chemical for a season is the sum of the transport for all samplings within the season. The seasonal concentrations were calculated by dividing the total seasonal chemical transport by the total water flow for that season.

RESULTS AND DISCUSSION
Average annual precipitation for the first 5-yr period (1122 mm) and the second 5-yr period (1147 mm) were similar. Precipitation was relatively well distributed throughout the year with greater amounts being received during the growing season than the dormant season Table 1). Because evapotranspiration is much greater during the growing season, subsurface flow was much lower during the growing season, being less than 25% of the precipitation. Dormant season subsurface flow was over 50% of precipitation. The subsurface flow and nutrient transport from the three summer-grazing areas were similar, and thus an average of these sites is presented in Table 1. The winter-feeding area had similar levels of nutrient loss except for greater Cl losses during the first period and greater transport of Mg and Cl during the second period (higher N rate).

The seasons of greater subsurface flow were also the periods for the greater nutrient losses (Table 1). Average annual losses K, Ca, and Na were similar for both 5-yr periods Losses of P and TOC were less during the second period than during the first; Mg and Cl losses during the second period were much greater than during the first period. Concentrations of nutrients changed very little on a seasonal basis, but over the 10 years, some trends could be observed (Figure 1). The greatest increases occurred with Mg and Cl; K increased slightly at the end of the 10 yrs; and Na changed very little. These data indicate that continuous years of grazing have a greater impact on non-nitrogen nutrients leaching to groundwater than the level of N applied during those grazing years.

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Table 1

Average nutrient losses in groundwater from under three summer-grazing paddocks for the growing season (May through October), dormant season (November through April), and annual period (May through April)

	Subsurface flow mm	Tot P	Sol K	Sol Ca kg/ha	Sol Mg	Sol Na	Sol Cl	TOC
Five-year average (1974-79)								
Growing season	74	0.08	1.3	10.4	5.1	3.8	4.7	6.1
Dormant season	304	0.24	5.0	41.3	19.4	14.3	19.0	19.9
Annual	378	0.32	6.3	51.7	24.5	18.1	23.7	26.0
Five-year average (1979-84)								
Growing season	151	0.04	2.7	20.0	11.7	6.9	11.2	3.0
Dormant season	262	0.06	5.4	38.9	21.4	11.6	30.5	7.4
Annual	429	0.10	8.1	58.9	43.1	18.5	41.7	10.4

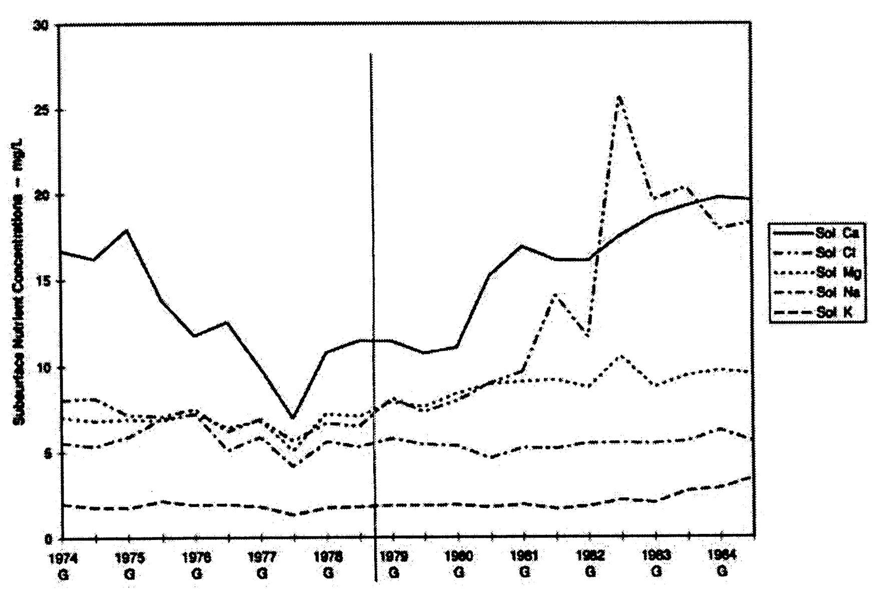

Figure 1

Subsureface ntrient concentrations for five non-nitrogen nutrients over a 10 year period. The plotted values are flow weighted averages for the Growing Season (May through October) and the Dormat Season (November through April). G = Growing season.